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Gregory Clark and Maximilian P McComb

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Centre for Economic Policy Research
33 Great Sutton Street, London EC1V 0DX, UK
Tel: +44 (0)20 7183 8801
www.cepr.org

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Abstract

If pre-industrial England was a Malthusian society, we should observe trendless living standards before 1800. Recent studies have claimed major gains in living standards 1270-1800 in northwest Europe, including England, implying the Malthusian era there had ended before 1350. Here we refute the claims that medieval English living standards were significantly lower than in 1800 using a variety of new metrics: the high value of food consumed per day when workers were fed at work, the high animal product share of the medieval diet, human heights, housing quality, and factor shares in agriculture. These measures all show the continued viability of the Malthusian interpretation: the medieval world was often richer than England of 1800.

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Gregory Clark - gclark@ucdavis.edu
University of California, Davis and CEPR

Maximilian P McComb - mpmcomb@gmail.com
Independent

Before the Dawn: English Medieval Living Standards and Economic Growth 1200-1800

Gregory Clark, Max McComb[1]

If pre-industrial England was a Malthusian society, we should observe trendless living standards before 1800. Recent studies have claimed major gains in living standards 1270-1800 in northwest Europe, including England, implying the Malthusian era there had ended before 1350. Here we refute the claims that medieval English living standards were significantly lower than in 1800 using a variety of new metrics: the high value of food consumed per day when workers were fed at work, the high animal product share of the medieval diet, human heights, housing quality, and factor shares in agriculture. These measures all show the continued viability of the Malthusian interpretation: the medieval world was often richer than England of 1800.

Introduction: The Debate over Pre-Industrial Living Standards

There is a deep puzzle about growth in Europe 1200-1800, before the Industrial Revolution. *A Farewell to Alms* (Clark, 2007) argues that before 1800 all societies, including England and the Netherlands, were Malthusian. This has three important implications. The first is that while incomes may have fluctuated before 1800, in the long run they were trendless, as high in 10,000 BC as in 1800. The second is that incomes were independent of technological improvements, and of the technological sophistication of early societies. The third is that pre-industrial incomes often exceeded those of many modern societies, since incomes by 1800 in countries such as England were good by the standards of a large fraction of the modern world.[2]

The mass opposed opinion has been that societies like England and the Netherlands escaped Malthusian constraints a considerable time before 1800. There was an intermediate period of growth in these societies, a Smithian phase, between the no growth Malthusian era

[1] Gregory Clark, University of California-Davis (gclark@ucdavis.edu), Maximilian McComb (mpmcomb@gmail.com).
[2] For the details see Clark, 2007b.

pre 1200, and the fast growth modern era.[3] By implication early pre-industrial societies, and in particular England before 1600, were at the income levels of the poorest modern countries such as Malawi or Tanzania. Figure 1 shows the picture of growth the early modernists prefer.

This picture is evident in some recent estimates of output per person in England and the Netherlands. Thus we have from Broadberry, Campbell et al., 2015, the estimated path of GDP per capita shown in figure 2. They estimate that between 1270 and 1801 GDP per capita grew at an average annual rate of 0.20 percent, so that by 1801 GDP per person was 3.2 times as great as in 1801.

Similarly van Zanden and van Leeuwen, 2011, report that output per person in the Netherlands was 2.75 times its level of 1347 by the 1790s, an implied growth rate of 0.22 percent per annum over these 450 years. Figure 3 shows their estimate of the growth of income per person in the Netherlands over these years. Gunner Persson suggests that the economy in pre-industrial Europe similarly had "upper bound" yearly growth rates of 0.2 percent per year (Persson, 2010, 71).

The evidence used to demonstrate the Malthusian propositions in *A Farewell to Alms* includes measures of pre-industrial real day wages in a variety of societies. Figure 4, for example, shows the estimated real day wages of workers in England from 1209 to 1869 (composed as an average of building and farm day wages). Real wages in the 1200s to 1790s exceeded those of 1800 in about half the decades. There is no sustained rise in real wages 1200-1800. Instead shocks to real wages associated with changes in population size dominate.

Real wages elsewhere tell a similar story of stagnation or decline between 1400 and 1800. In Italy, Spain, Sweden, the Netherlands, the Ottoman Empire, and Japan, there is no clear trend toward higher real wages as the Industrial Revolution approaches, but instead just swings associated with population movements.[4]

[3]See Allen, 2009, Broadberry, Campbell et al., 2015, de Vries, 2008, Humphries and Weisdorf, 2018, Maddison, 2007, Persson, 2008, Wrigley, 1985, van Zanden and van Leeuwen, 2011.

[4] See, for example, the real wage trends in north and central Italy, 1270-1800 (Malanima, 2007), Sweden 1365-1800 (Edvinsson and Söderberg, 2011, figure 8), the Netherlands, 1450-1800 (Van Zanden, 2002, figure 3), Antwerp, 1399-1800 and Valencia, 1413-1800 (Allen, 2001, figures 7 and 8), Ottoman Turkey 1480-1800 (Özmucur and Pamuk, 2002, table 1), Japan 1741-1850 (Bassino and Ma, 2005).

Figure 1: Stylized picture of the three regime view of economic growth

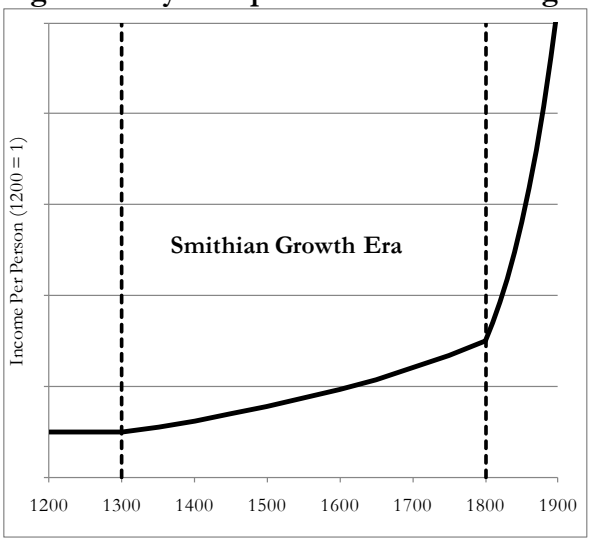
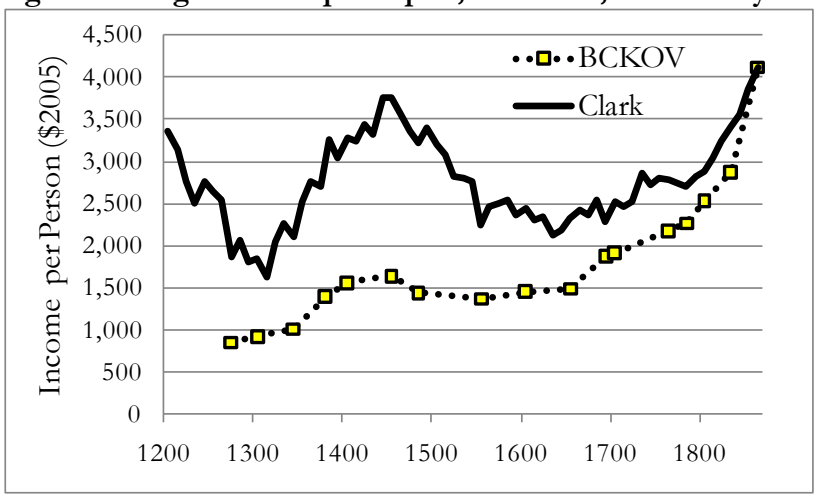


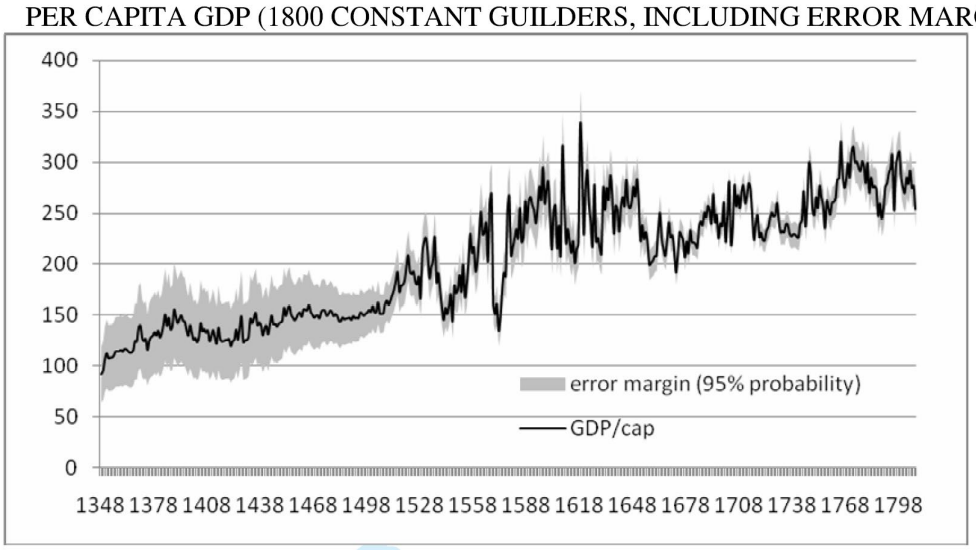
Figure 2: English GDP per capita, 1270-1870, Broadberry et al. versus Clark



Notes: The dotted line links the BCKOV benchmarks.

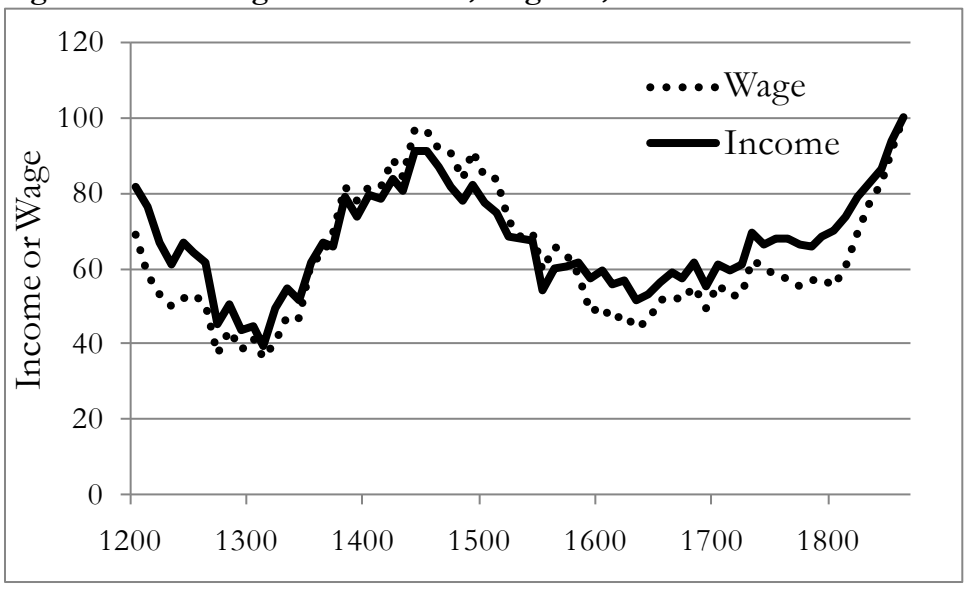
Sources: Clark, 2010a, figure 9, Broadberry et al., 2015, tables 19, 24.

Figure 3: Estimated Netherlands per capita GDP 1348-1800



Source: van Zanden and van Leeuwen, 2011, figure 1.

Figure 4: Real Wages and Income, England, 1200-1869



Note: 1860s = 100.
Sources: Clark, 2010, figures 8, 9.

The wage evidence thus is the foundational confirmation of Malthusian views of pre-industrial Europe, but an anomaly for the early modern consensus. To reconcile the clear evidence of day wages with the growth narrative the proponents of pre-industrial growth have had to posit that pre-industrial workers worked a much smaller number of days per year – as few as 100 – compared to workers around 1800. Thus Humphries and Weisdorf have recently derived the series shown in figure 5 for annual work days in England, based on the ratio of the earnings of workers on annual contracts compared to those on daily contracts. Note that they estimate annual average work days as 100 in 1360, and as nearly 350 by 1850. The worker in 1360 thus has a calculated 2 day week, while the worker of 1850 has a near 7 day week.

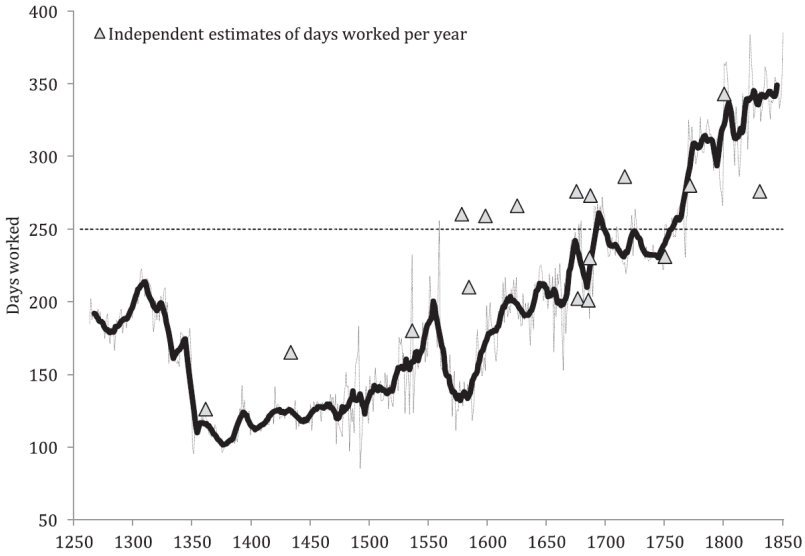
We can see also in figure 5 a near tripling of implied days worked per year between 1600 and 1850. This has been dubbed by Jan de Vries the *Industrious Revolution:* a supposed increase between 1500 and 1750 in the numbers of days worked per year by men, and in the labor inputs of women and children.

In England the wage information can be combined with measures of total land rents, house rents, and other property returns to estimate all income per person, also shown in figure 4. Adding this other information modifies the wage evidence, but the basic pattern remains. This broader measure confirms the idea that in many decades pre-industrial England had higher estimated incomes than in 1800 in the early Industrial Revolution (Clark, 2010).[5]

In this paper we consider five other measures of medieval English living standards to see which view of medieval incomes they support. First we derive measures of what the cost of feeding a worker was per day 1350-1834. If medieval workers were only working 100 days per year then each day's earnings at work had to feed the medieval worker over nearly 4 days, compared to 1.2 days for the worker in 1800. That implies that the cost of the diet for a worker fed at work had to be a much smaller share of the wage for the medieval worker as for later workers. We show that the food cost share of the wage was just as high in 1450 as in 1800. Further we show that workers in 1450 ate 30-70% more food at work in terms of value

[5] These national income estimates were premised on a share of the population employed in farming of 60 percent in the years before 1680.

Figure 5: Estimated annual work days, Humphries and Weisdorf



Source: Humphries and Weisdorf, 2019, figure 4, p. 2880.

than those of 1771-1834. This evidence on feeding costs is supported by two types of evidence on the high quality of the medieval diet. The first is the ratio of animal product sellers to bakers in medieval England compared to early nineteenth century England. Medieval England had many more butchers and fishmongers compared to bakers then did early nineteenth century England. But second the skeletal remains of the medieval English show clear evidence through nitrogen isotope ratios of a diet rich in animal proteins even by the standards of modern England. This evidence on diet is supported by evidence on the amount of floor space in housing the average medieval English peasant consumed. This is 2-3 times what we would expect based on the new income estimates. The skeletal evidence also shows clearly that the English in the period 1200-1500 were as tall as they were in 1800, despite incomes in 1800 being estimated at 2.5 times their level in 1270. Finally the estimates of a 100 day work year 1350-1500 imply that the value of output from each acre of farmland is well below the costs of labor, land rents, and capital costs. All five of these measures show that there is no sign of any gain in living standards 1200-1800, in line with the Malthusian interpretation.

Daily Food Consumption of Workers

In the years 1200-1800 workers paid by the day in England were mostly paid with cash only. But sometimes they were fed and lodged on the job, and then received a lower monetary payment. An example is building workers repairing farm buildings away from their homes. Where we observe for the same location the day wage of (for example) a carpenter at 4d. without food, and 2.5 d. with food (ad mensa), then the implied share of the day wage spent on a day's food for a worker is 38%. For a subset of places 1350-1834 we get observations on the wages of workers both receiving just cash and those fed while at work.[6] Table 1 summarizes those observations.

The number of days workers worked per year has implications for what share of the wage would be observed being spent on food for the worker. For if a worker works only one day in every 3.65, as would be implied by a work year of 100 days, then their daily cost of food would have to be no more than 27% of the day wage, assuming they eat the same amount on work and non-work days. But we can get a better estimate of that expected ratio by using 1834 as a base. In this period we know the work year was 300-313 days per year (see Clark and van der Werf, 1998). We also see in table 1 that the share daily food costs were of wages for rural workers was 0.40. With a proposed work year of 100-150 days per year 1350-1602 (see figure 5), that ratio should be closer to 0.15-0.20. Instead for the years 1350-1602 the average was nearly the same at 0.41.

Now, in the Smithian Growth narrative for 1200-1800 seen in figure 2, wages in the years 1350 to 1650 would be only about 50% of those in 1834, and so the share of laborers income spend on food would be expected to be higher. However, what would be strongly predicted is that food expenditures per day for workers would still be substantially less than in 1834. The last two columns in table 1 show the real day wages 1350-1834 of farm laborers, and the implied food expenditure per day of these workers, which is the nominal food expenditure deflated by a food cost index for workers. Figure 1 shows these real wages and real daily food costs for 1350-1869. Two things stand out. First the food expenditures per day on farm laborers 1350-1602 all exceeded those of 1834, despite material living standards supposed to be at only a half those of 1834. In some periods, such as 1450-99, the estimated expenditures were nearly 70% higher. The 15th century really was a Golden Age for laborers.

[6] As noted, some of these workers would also be lodged, but in the rural areas where most of these observations come from this was not a substantial cost. Also the incident of this extra expense for the employer would not be expected to be greater in 1834 than in 1350.

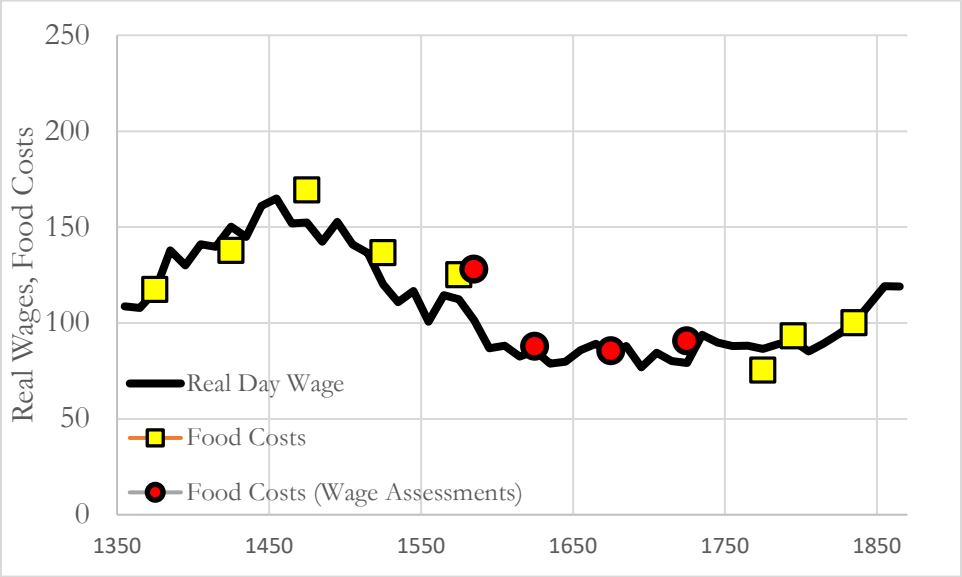
Table 1: Daily Food Consumption by Workers, 1350-1834

Period	Observations	Food share of Wage	Real Farm Wage (1830s=100)	Real Daily Food Cost (1830s = 100)
1350-99	8	0.36	120.2	117.4
1400-49	61	0.34	147.4	137.6
1450-99	91	0.41	152.8	169.1
1500-49	10	0.43	125.0	136.5
1550-1602	12	0.52	103.1	125.0
1560-99*	17	0.52	103.7	127.9
1600-49*	12	0.45	82.9	87.7
1650-99*	14	0.42	84.7	85.4
1700-32*	2	0.44	81.2	90.5
1771	52	0.36	86.5	75.3
1793-96	7	0.43	90.6	93.1
1834	35	0.40	100.0	100.0

Notes: * indicates observations from wages assessments by local magistrates 1562-1732. Such assessments were generally below current market wage rates, but the ratio of wages with and without food should not be affected.

Sources: See Appendix 1.

Figure 6: Real Food Costs per Day, Farm Laborers, 1350-1869



Source: Table 1.

The second thing that stands out in figure 6 is that food costs closely track real day wages. This is because the food cost share is fairly close to 0.4 all through these years. Thus real day wages seem to index real living standards closely throughout these years, implying there were no substantial changes in days worked per year.

Since the number of calories per day consumed does not vary much once people reach the material living standards of 1800, the higher daily food costs of 1350-1550 would come mainly from the consumption of more expensive calories. For the consumption choices of 1350-1600 that would imply more meat and dairy products as opposed to grains, and more expensive forms of grain consumption such as alcohol. Below we show evidence that meat/dairy was a more substantial part of the English diet in 1350-1550 than it was 1800-1850, and indeed than it is even now.

Food Consumption Patterns

There are predictable shifts in patterns of food consumption as economies get richer. There is a steady shift from foods that are cheap per calorie of energy supplied, to those that are more expensive. Thus animal foods such as meat, fish, milk and cheese become an ever larger share of the diet compared to grains and starches.[7] The pattern of employment of different types of food suppliers can thus also be used as a proxy for living standards.

The patterns of employment in the towns of medieval England indicates again very clearly high material living standards. This is illustrated well by Maryanne Kowaleski's fine study of medieval Exeter circa 1377. Using tax rolls, court rolls, and a variety of other sources she is able to identify 525 known householders in the city in 1377, when the overall population is estimated at 3,101. Of the known household heads 13 were identified as bakers, 14 as butchers and 14 as fishmongers as their primary occupation.[8] We get an indication of the relative wealth of these purveyors from their average murage tax in 1377. This suggests that the butchers were the wealthiest group (average tax 20.2 d.), followed by bakers (11.9 d.) and then fishmongers (9.1 d.). This is reflected also in the estimated number of servants per household being 0.86 for butchers, 0.69 for bakers and 0.57 for fishmongers.[9] Thus overall we would expect that the relative numbers of bakers versus butchers plus fishmongers will reflect the relative consumption value of these two types of products – bread versus meats - in the late medieval diet. That implies expenditure on animal products was twice as great as that on grains. We can also measure expenditure on animal products per capital through the ratio of the meat and fish purveyors to the population as a whole. This was 9.0 per thousand.

To see how the ratio of grain purveyors to animal product purveyors in Exeter in 1377 compares to England in 1850 we can use county directories. Since they gave for each town and district in a county a list of the various tradesmen and shopkeepers they are a comparable source to the medieval tax and court case lists which identify medieval purveyors and tradesmen. For Devon we have William White's *History, Gazetteer and Directory of Devonshire*, published 1850. Table 2 shows the comparable data on the numbers of bakers and animal product purveyors in a set of Devon towns in 1850 where we have a complete set of food sellers listed. The ratio of butchers to bakers is consistently lower in 1850. And the numbers

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[7] See Clark (2007), chapter 3, 40-70.

[8] Kowaleski (1995), table 4.2, pp. 128-9. As a reflection on how recent was the formation of surnames in England in 1377, 5 of the 13 bakers had the surname "baker" and 2 of the 14 butchers had the surname "butcher."

[9] Kowaleski (1995), table 4.2, pp. 128-9. Murage was a property wealth tax.

Table 2: Ratio of Butchers to Bakers, Medieval England versus 1850

Period	Location	Population	Bakers	Meat-Dairy-Fish	Meat/ Baker	Meat/ Population (/1000)
1377	Exeter	3,101	13	28	2.15	9.0
1850	Tavistock	8,086	12	24	2.00	3.0
1850	Tiverton	11,144	29	33	1.14	3.0
1850	Devonport	38,180	100	150	1.50	3.9
1850	Exeter	40,688	110	171	1.55	4.2
1850	Plymouth	50,159	112	186	1.66	3.7
1837-79	England	3 m	16,429	19,315	1.21	-

Notes: Male occupations only. Bakers includes confectioners in 1850. Meat-Dairy-Fish includes butchers, cheesemongers, dairymen, fishmongers, and poulterers.
Sources: Exeter, 1377, Kowaleski, 1995. Devon, 1850, White, 1850 (purveyors), Edwards, 1854 (town sizes 1851). 1837-79: 334,004 marriage certificates from England and Wales, https://www.freereg.org.uk/

of animal product purveyors per 1,000 of the population is again significantly lower in 1850. Table 2 also shows the numbers of bakers versus animal product purveyors in marriage records 1837-1979 in England, where the sample is composed of around 3 million grooms, fathers and fathers-in-law. Again bakers and confectioners are much more prevalent compared to butchers than in late medieval Exeter.

We can also see that Exeter is not unusual for towns in medieval England in the high ratio of butchers to bakers, and in the high numbers of butchers per 1,000 of population. Table 3 shows a summary for medieval England of the totals for bakers versus those that retail animal products. These retailers are identified either from their appearance in court rolls, or in town rentals, or from the poll tax records of 1377-81.

Table 3: Ratio of Butchers to Bakers, Medieval England

Period	Location	Population	Bakers	Meat-dairy-fish	Meat/ Baker	Meat/ Population
1289-1319	Lincoln	4,000	14	17	1.21	4
1320-49	Lincoln	4,000	12	26	2.17	7
pre 1339	Winchester	11,000	27	35	1.30	3
1350-79	Lincoln	2,500	11	25	2.27	10
1377	Exeter	3,101	14	28	2.15	9
1377-9	Poll Tax		49	100	2.04	
1380-1409	Lincoln	2,000	4	20	5.00	10
1400-1415	Ipswich	2,900	4	16	4.00	6
1390-1529	Winchester	7,750	26	68	2.62	9
1455	Gloucester	5,000	7	9	1.29	-
1486-1500	Ipswich	2,900	4	22	5.50	8

Notes: Male occupations only. Bakers includes confectioners. Meat/Dairy includes butchers, cheesemongers, dairymen, fishmongers, milkmen, and poulterers.
Sources: Ipswich, Amor, 2011, pp. 97, 203, Winchester, Keene, 1985, Lincoln, Kissane, 2017, Exeter, Kowaleski, 1995, pp. 128-129, Poll Tax, Fenwick, 1998, 2001, 2005.

Even in the years 1289-1349, which include the period where English real day wages show their lowest level 1209-1800, animal product sellers consistently appear in higher numbers than bakers. If sales per worker were the same in both types of retail enterprise, then in towns at least, people were spending a higher share of their income on animal products than on bread.

After the plague the ratio of butchers/fishmongers to bakers rises substantially. It goes from an average of 1.6 to 3.3. The implication is of a society where expenditure on meat and dairy products greatly exceeded that on grains. Note that preponderance of sellers of meat/dairy versus grain products in the period 1350-1500 is even stronger than we observe in the early nineteenth century.

If we look at the absolute numbers of meat and dairy product sellers in medieval England per head of population, we see that these averaged 5 per 1000 in towns before the onset of the Black Death, and 9 per 1000, in line with higher daily wages, 1350-1550. For 1850 in

contrast they average was again just 4 per 1000 of population. So again there is no sign here of any gain in living standards even 1300-1800, indexed by the share of income being spent on meat and dairy products.

Archeological Evidence on Consumption: Diet and Stable Isotopes

The many surviving skeletons of medieval England reveal evidence also of a diet high in animal protein. For diets have an effect on the proportions of isotopes of nitrogen and carbon in the human body.[10] In particular, richer people who eat a diet with a larger proportion of meat, fish and dairy products will have in the tissues of their bodies – bones, nails, hair and tooth enamel – a higher proportion of the heavier isotope of Nitrogen, 15N (0.37% in nitrogen in air) than of the lighter isotope 14N (99.63% in air). Similarly people with a high proportion of marine animals in their diet will have more of the heavier 13C isotope of carbon than of the lighter 12C. Since marine fish are particularly rich in 15N the carbon isotope ratios can be used to rule out a high 15N ratio that came not from heavy animal protein consumption, but instead from a modest diet of 15N rich marine protein.

In archeological and other investigations the proportion of heavier nitrogen isotopes in tissue is reported as δ15N‰, where

$$\delta 15N‰ = \frac{\left(\frac{15N}{14N}\right)_{sample} - \left(\frac{15N}{14N}\right)_{air}}{\left(\frac{15N}{14N}\right)_{air}} \times 1{,}000$$

and the reference material is nitrogen in the atmosphere. The proportion of the heavier 13C Carbon isotope is reported as

$$\delta 13C‰ = \frac{\left(\frac{13C}{12C}\right)_{sample} - \left(\frac{13C}{12C}\right)_{reference}}{\left(\frac{13C}{12C}\right)_{reference}} \times 1{,}000$$

The $\delta 15N‰$ ratio rises with each level in the food chain. Animals have $\delta 15N‰$ values that are 3-4‰ higher than their diet. Thus humans who ate only animal foods would see an increase of 3-4‰ in this ratio compared to vegans. In the hair and nails of modern subjects from England and Germany omnivores showed an average +3.2 δ15N‰ level compared to

[10] Where isotopes of atoms are variants which differ just in the numbers of neutrinos.

vegans in the same countries (Thompson et al., 2010, table 5, p. 447). The level of δ15N‰ in hair is also higher in high income countries, where the diet contains more animal products, than in low income ones. In 2010 for omnivores in the USA, England, Germany and Denmark δ15N‰ averaged 9.6. In contrast in India, Pakistan and China the average level in hair was 8.1 ((Thompson et al., 2010, table 2, p. 444). For archeological purposes the δ15N‰ and $\delta 13C‰$ measures are estimated from bone collagen, or from tooth enamel. O'Connell et al., 2001, show that this bone measure will be inflated by an average of 0.9 for δ15N‰, and 1.4 for $\delta 13C‰$ compared to the hair measure (O'Connell et al., 2001, table 1).[11] Thus if we find in medieval skeletons a reading for δ15N‰ of 10.5 or above it would indicate a diet as rich in animal products as for modern high income societies. If we find instead a reading of 7.3 or below it would indicate a diet largely free of more expensive animal food.

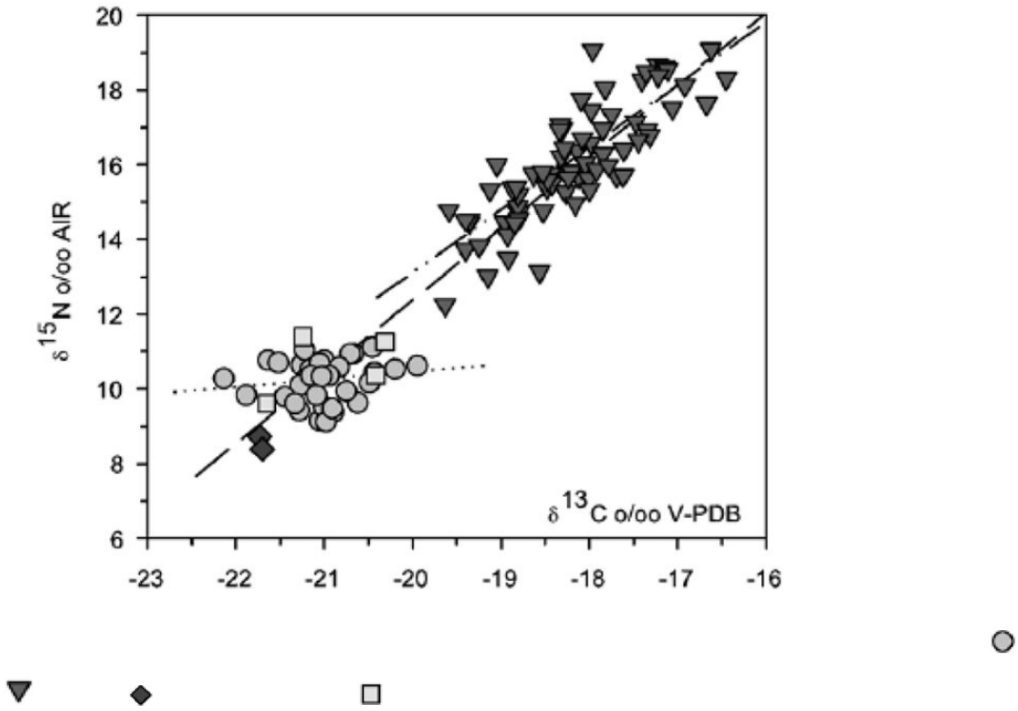
However, an important complication we have to deal with is the significant fish consumption of medieval society. We see from the court records of towns that fishmongers were a significant share of meat sellers in medieval England. The English diet then included substantial amounts of cod and herring. Until the fifteenth century Church fasting rules in England banned meat and dairy products, but not fish, for as much as one third of days.

Marine fish consumed by humans such as cod or halibut are highly predatory, and so also have elevated $\delta 15N‰$ values. Food chains also tend to be longer in the marine environment. (O'Brien, 2015). Thus high $\delta 15N‰$ values found in skeletons in medieval England could indicate high rates of animal product consumption (and hence high incomes), or they could indicate more modest animal product consumption, but heavily concentrated on marine fish. So we need to rule out this possibility.

We can do so because a marine animal diet has a distinctive marker in also having a high $\delta 13C‰$ ratio. This is illustrated by a modern study of the $\delta 15N‰$ and $\delta 13C‰$ ratios of three groups of people – modern Danes, modern vegan Danes, and Greenland Inuit who have a diet very high in marine animals. As figure 7 shows the Inuit have very high levels of both $\delta 15N‰$ and $\delta 13C‰$. But for every 1 unit marine food increases $\delta 15N‰$ it will increase $\delta 13C‰$ by 0.5 units. Thus a significant inflation of $\delta 15N‰$ levels in medieval English skeletons through fish consumption will leave a clear trace in also an elevated $\delta 13C‰$ level.

[11] For nail measures bone collagen is inflated by 0.2 for $\delta 15N‰$, and by the same 1.4 for $\delta 13C‰$ $(O'Connelet\ al., 1253)$.

Figure 7: $\delta 15N‰$ versus $\delta 13C‰$ ratios, Modern Danes and Inuit

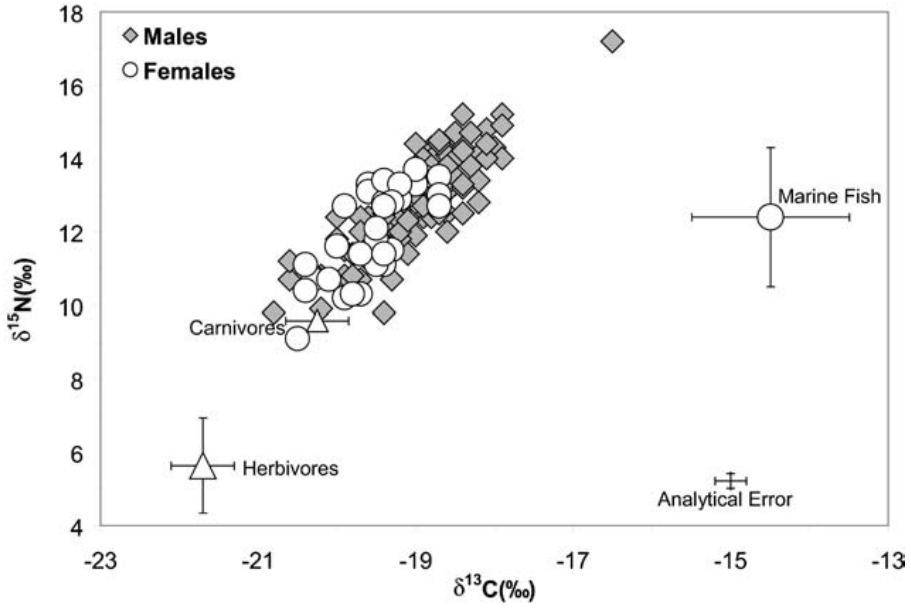


Source: Buchardt, Bunch, and Helin, 2007, Figure 4, p. 321.

Based on the Danish data in figure 11, if medieval people were eating a larger proportion of marine fish in their diets than modern Danes, then the $\delta 13C‰$ measure in bone collagen should be greater than -19.6. We shall see that the high medieval $\delta 15N‰$ levels cannot be explained by a diet that was largely grains but with 10-20% of calories from marine fish. These high $\delta 15N‰$ levels came mainly from high levels of consumption of terrestrial meat and dairy products.

We see a demonstration of this in figure 8, which shows for individual skeletons in St Andrew Fishergate in York, 1200-1538 the $\delta 15N‰$ and $\delta 13C‰$ readings. The $\delta 15N‰$ levels on average were high relative to the 10.9 level expected for modern northern Europeans. There is also clear evidence that the medieval dead with the highest $\delta 15N‰$ readings were those consuming the most fish. There is a strong positive association between $\delta 15N‰$ levels

Figure 8: Human stable isotope data, St Andrew Fishergate in York, 1200-1538.



Source: Müldner, 2008, figure 16.4, p. 337.

and $\delta 13C‰$ levels. However, if we take people whose skeletal $\delta 13C‰$ levels was -19.6, which would be the expected level for modern northern Europeans given moderate fish consumption, then that is associated with an average $\delta 15N‰$ level of 12.0, which is above modern northern European levels (10.9). Those dying in York 1200-1538 who did not have a lot of fish in their diet show signs of consuming more animal products even than modern northern Europeans. By implication these were people living at high income levels.

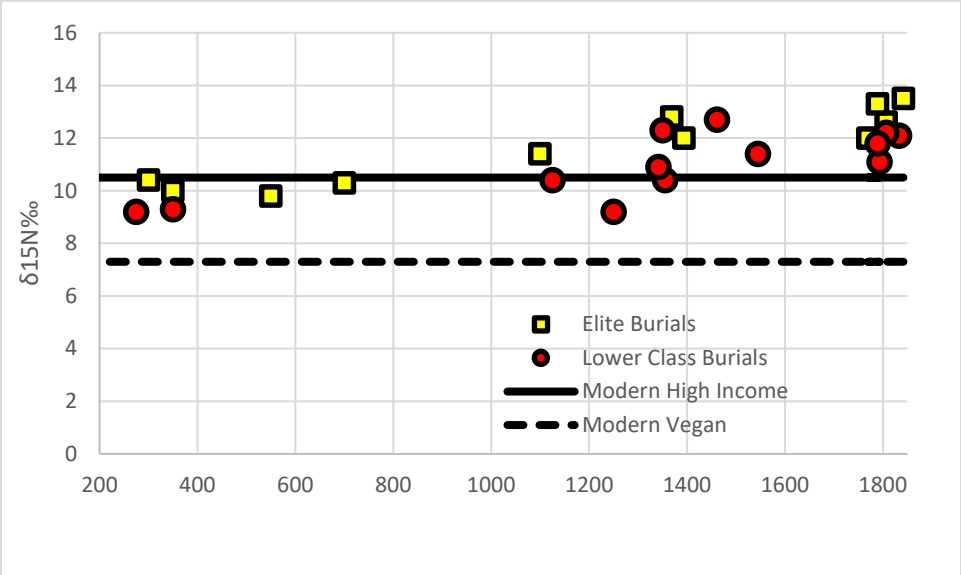
Table 4 summarizes studies of stable isotopes in skeletal remains in England from the late Roman period to the early nineteenth century, in reverse chronological order. Figure 9 plots these observations for δ15N‰, the indicator of the share of food that was animal products, by midpoint of the burial date ranges. In the figure low status burials, including seamen and soldiers, are indicated by a red circle, and burials that were predominantly higher status by a yellow square. Indicators of low status burials earlier were burial in a shroud as opposed to a coffin or crypt, or the absence of objects buried along with the person indicating higher status.

Table 4: Stable Isotope Evidence of Diet in Pre-Industrial England

Location	Social Group	Dates of Death	δ15N‰	δ13C‰
Modern High Income Omnivores[10]	All	-	10.5	-18.2
Modern Low Income[10]	All	-	9.0	-18.8
St Barnabas, Kensington[1]	Elite	1831-1853	13.5	-19.1
St Lukes, Coventry[11]	Weavers	1820-1847	12.1	-19.5
Chelsea, London[11]	Elite	1781-1836	12.6	-18.9
Queen's Chapel, Savoy, London[1]	Soldiers	1760-1854	12.2	-19.4
Navy Seamen, Plymouth[9]	Seamen	1762-1824	11.1	-18.8
Navy Seamen, Gosport[9]	Seamen	1753-1826	11.8	-20.1
St Martins, Birmingham[1]	Elite	1750-1850	12.0	-19.2
Spitalfields, London[5]	Craftsmen	1729-1849	13.3	-18.8
Mary Rose Shipwreck[9]	Seamen	1545	11.4	-19.4
Towton[4]	Soldiers	1461	12.7	-19.4
Plague Pits, Hereford[2]	Common	1349, 1361	10.4	-19.6
St Giles Hospital, Yorkshire[4]	Almsmen	1250-1450	12.3	-19.2
Augustinian Priory, Warrington[4]	Elite	1250-1538	12.0	-19.8
Gilbertine Priory, York[3]	Elite	1200-1538	12.8	-19.1
St Guthlac's Priory, Hereford[2]	All	1144-1539	10.9	-19.4
Cathedral Close, Hereford[2]	All	1100-1150	10.4	-19.6
St Andrews, Fishergate, York[3]	Elite	1000-1200	11.4	-19.7
Wharram Percy, North Yorkshire[8]	All	950-1550	9.2	-19.6
Anglo-Saxon York[3]	All	650-750	10.3	-20.0
Anglo-Saxon, Berinsfield, Oxfordshire[6]	All	450-650	9.8	-19.9
Roman Dorchester[7]	Elite	300-400	10.0	-18.2
Roman Dorchester[7]	Common	300-400	9.3	-19.5
Roman York[3]	All	200-400	10.4	-19.7
Roman York[3]	Common	150-400	9.2	-19.4

Notes: Measures for the living of δ15N‰ and $\delta 13C‰$ adjusted to bone measure equivalents.
Sources: [1]Bleasdale *et al.* 2019, [2]Hrafnhildur et al., 2019, [3]Müldner and Richards, 2007a, table 3, [4]Müldner and Richards, 2005, [5]Nitsch, Humphrey, and Hedges, 2010, table 3, [6]Privat, O'Connell, and Richards, 2002, [7]Richards, et al. 1998, Table 2, [8]Richards, Mays, and Fuller, 2002, [9]Roberts et al., 2012, [10]Thompson et al., 2010, tables 2 and 5, [11]Trickett, 2006.

Figure 9: δ15N‰ in English burials, 200-1850 BCE



Source: Table 4.

Also shown in the figure is the δ15N‰ level for modern high income omnivores, and for modern vegans. As the figure shows the English from the post plague period onwards seem to have had a diet that was more meat intensive than for modern omnivores. In table 4 the $\delta 13C‰$ readings show that this was not driven by high levels of fish consumption. The $\delta 13C‰$ scores are indeed remarkably consistent over the years 200-1800 at an average of -19.4, implying less marine fish as a proportion of the diet than for modern consumers. The second feature that appears in figure 13 is that the animal product consumption levels are nearly as high in 1350-1545 as circa 1800, despite the supposed 70% rise in incomes per person between these dates. Also the levels of animal product consumption for deaths 1350-1545, even for the poorer consumers, are high relative to modern high income omnivores.

Note that even medieval burials before 1350, and burials in the Roman and Anglo-Saxon periods, show levels of heavier Nitrogen that all imply levels of animal product consumption that are close to those of modern high income societies.

Table 5: Food rations per man stipulated by the Victualling Board in the mid-18th century

	Bread	Beer	Beef	Pork	Peas	Oatmeal	Butter	Cheese
Sunday	1 lb	1 gal		1 lb	0.5 pt			
Monday	1 lb	1 gal				1 pt	2 oz	4 oz
Tuesday	1 lb	1 gal	2 lbs					
Wednesday	1 lb	1 gal			0.5 pt	1 pt	2 oz	4 oz
Thursday	1 lb	1 gal		1 lb	0.5 pt			
Friday	1 lb	1 gal			0.5 pt	1 pt	2 oz	4 oz
Saturday	1 lb	1 gal	2 lbs					

Note: gal = gallon, pt = pint.

We can calibrate that the high δ15N‰ scores do indeed indicate high levels of meat consumption for the case of the Royal Navy seamen buried at the Naval hospitals at Plymouth and Gosport, and from the wreck of the Mary Rose, which sank in 1545. In this case, we know their diet from the regulations of the Navy. The diet for the eighteenth century is shown in table 5. The diet included 1 lb of meat/dairy per day, but no fish. Thus, the majority of protein input, the protein forming the bone collagen, was coming from terrestrial animal inputs. Hence the high levels of δ15N‰. In 1545 Navy rations were very similar to those of 1800. The evidence of Navy seamen shows that the isotope analysis of skeletal remains will identify a diet high in animal proteins, and can also show the absence of large quantities of fish in the diet. Note that the casualties of the battle of Towton in 1461 buried in common graves at the battlefield have δ15N‰ levels which are

The high levels of the heavier isotope of Nitrogen in the bones of the sailors is exceeded, however, by the levels found in burials for late medieval York. For burials in the Gilbertine Priory cemetery in York from 1200-1538, for example, the average of δ15N‰ is 12.8. Those buried here included the monks, but also lay benefactors of the Priory, as well as servants and laborers who worked there. Thus, it was a mixture of high and modest status individuals. However, the lower status individuals buried outside the church had levels of δ15N‰ as high as those of the high-status persons buried within the monastic walls (Müldner and Richards, 2007b). The $\delta 13C‰$ measure implies also that these individuals had a largely terrestrial diet. Thus late medieval consumers had a diet high in animal proteins, and implying high overall incomes to afford such diets.

Heights

The excavated skeletons of medieval England also provide evidence on heights. Heights are a reasonable indicator of material living standards, particularly for poorer populations where nutritional constraints are binding. Thus since 1800, and the modern improvement of living standards and child health, heights have increased significantly in England. The large sample of skeletal remains utilized here for England 900-1800 shows an average male height of 170.6 cm (67.1"). In contrast the average height of males in England aged 25-34 in 2012 was 177.8 cm (70.0").[12]

To estimate heights in England 900-1850 we utilize all available records of skeletal heights within these years. Height data was collected from skeletons uncovered by archaeological excavations of medieval and later cemeteries in England. The largest number of surveyed medieval skeletal remains comes from cemeteries excavated in and around London. There are ten such London medieval cemeteries surveyed in this study: Bermondsey Abbey, East Smithfield, Dominican Friary at Carter Lane, Guildhall Yard, Merton Priory, St Benet Sharehog, St Mary Graces, St Mary Spital, St Nicholas Shambles, and St Thomas Hospital.

Skeletons found in Yorkshire represent the second largest group of skeletons included in the sample with eight cemeteries:, Towton, Saint Helen at Aldwark, Fishergate, Clementhorpe, Jewbury, Pontefract Priory, York Minster, and Wharram Percy.

The sample includes two cemeteries from Northamptonshire, Raunds and Rothwell Charnel House, two sites from Kent, Rochester Cathedral and St Leonard's, Hythe, and two from Norfolk, Barton Bendish and South Acre. The rest of the sample consists of single cemeteries from other places in England. These are St John's Hospital in Cambridge, Dominican Priory in Chelmsford, Greyfriars in Chester, Durham Cathedral, Langthome in Essex, St Bride's Lower Churchyard in Farringdon, Crowland Road cemetery in Haverhill, Baldock in Herfordshire, Jewson's Yard in Hertford, St Edmonds in Kellington, Austin Friars in Leicester, St Peters (Barton-on-Humber) in Lincolnshire, Litten in Berkshire, Chichester in West Sussex, St Mary Magdalene in Winchester, and Bordesley Abbey in Worcestershire. One

[12]Moody, Alison (18 December 2013). "10: Adult anthropometric measures, overweight and obesity". In Craig, Rachel; Mindell, Jennifer. Health Survey for England – 2012 (PDF) (Report). Volume 1: Health, social care and lifestyles. Health and Social Care Information Centre. p. 20.

of the cemeteries included in the sample housed human remains from a Jewish community: Jewbury, in Yorkshire, dated to between 1200 and 1299 – before or shortly after the expulsion of England's Jewish communities by King Edward II in 1290.

The dates for these medieval skeletal collections range from ca. 900 to ca. 1538. The dating of this evidence tends to be loose. A graveyard will often have been used for hundreds of years. It is possible to assign a relatively precise date to each skeleton excavated from the graveyard, but this requires radiocarbon dating which is expensive. Thus, for many of these collections we have only a broad date range. In several cases, more precise dates can be determined. For example, East Smithfield, a Black Death cemetery from London, can be dated to between 1348 and 1350, just after the June 1348 arrival of the plague in England. Written evidence connected to the nearby Church of the Holy Trinity reveals that East Smithfield was founded in autumn 1348 in order to house the remains of plague victims. Excavations in the 1980s further found no evidence that the cemetery was used after 1350.[13] Likewise, the burial ground at Towton, North Yorkshire contains casualties of the battle fought there on 29 March, 1461 and can be firmly dated to shortly after that date.[14]

Archaeologists have also conducted radiocarbon dating on human remains uncovered during excavations conducted at the churchyard of Wharram Percy, an abandoned medieval village in North Yorkshire.[15] Simon Mays used this dating to categorize the skeletal remains into four phases of burial. Phases 1 (950-1065) and 2 (1066-1348) comprise the medieval skeletal remains found at Wharram Percy. In most cases, however, no radiocarbon dating has been performed on English medieval skeletal finds and accordingly more precise periodization is unavailable.

Taller height is correlated with higher social status. In some of the sample skeletal collections it is possible to ascertain information about the social class of the individuals. The social status can be determined according to a variety of factors. The presence of higher status individuals is occasionally confirmed by written wills, which were only left by those of more substantial means. Likewise, the institutional context of burial sites sometimes also suggests more higher status individuals, as is the case for cemeteries used by English monastic communities. Higher status is also often indicated by material objects or clothing found with skeletal remains or by burial in coffins, which correlates with higher status. Finally, certain

[13] DeWitte and Hughes-Morey (2012); DeWitte and Slavin (2013),
[14] Fiorato et al. (2000)
[15] Mays (2007)

injuries to the skeleton inflicted in life indicate professions involving regular intense manual labor, thus suggesting lower status.

Several of the surveyed cemeteries housed the remains of members of monastic communities, indicating higher social status and a higher daily caloric intake. These monastic cemeteries are Langthome and Bermondsey Abbey. Other similar clerical or monastic cemeteries feature a mix of high-status monks or clerics and lay people attached to the community: Fishergate, St Mary Graces and Merton Priory. The body of a twelfth-century pilgrim uncovered at Winchester and studied in detail was also likely a high-status individual given the clothing and items with which he was buried.[16]

In contrast, the skeletal remains uncovered at St Peters (Barton-on-Humber) and St Thomas Hospital were of individuals of middling and lower social status. Other cemeteries attest a mixture of social statuses. The cemeteries at Raunds and Wharram Percy were used by all members of the nearby communities, suggesting a wider range of social statuses. Likewise, the soldiers whose remains were excavated at Towton were of heterogeneous social background.[17] The medieval cemetery uncovered at Haverhill, Suffolk, also likely housed a mix of high and low status individuals. Fifteenth-century wills provided archaeologists with evidence that burials were taking place near a particular church on the site.[18] The existence of such wills indicates individuals of greater relative wealth, a picture confirmed by the recovery of scraps of clothing and personal effects uncovered during excavation.

The cemeteries of St Peters in Lincolnshire and St Nicholas Shambles likely contained the remains of individuals of lower social status. Those buried at St Peters were mostly traders or small-scale peasant farmers. Likewise, the male skeletons at St Nicholas Shambles reveal a high rate of an injury to the lower vertebrae – referred to as the "clay-shovellers fracture" – most often caused by habitual manual labor.[19] Eight of the bodies excavated at Austin Friars in Leicester display similar injuries, suggesting the burial site was at least partially comprised of manual laborers.

To aggregate this data we ran a regression by 100 year intervals where

[16] Roffey et al. (2017)
[17] Fiorato et al. (2000)
[18] Murray (2005)
[19] White(1988); Daniell (1996)

$$Height_{ikt} = \alpha_1 Dfem_k + \alpha_2 Delite_i + \sum_{t=900}^{t=1800} \beta_t Dcentury_t$$

Dfem is an indicator for a woman, Delite is an indicator for an elite burial ground, Dcentury is an indictor for burials in century t, i indexes a skeletal collection, t indexes the centuries in which burials occurred in that location, and k indexes male/female. Average height from men and women at each location formed the dependent variable *height*. If a cemetery had burials 1215-1403 when it was counted as an observation from 1200-99 and one from 1300-99. A cemetery was not counted (except for the years 1800-1850) as having an observation in a century if it spanned fewer than 50 years of that century. The regression was weighted by the average numbers of skeletons per century of observation from each location.

Table 6 shows the estimated values of $\alpha_1$and α_2, as well as the estimated β coefficients which differed significantly from the average of the whole sample. The only two centuries that deviated significantly were 1300-99 where heights were below average and 1400-99 where heights were above average. Figure 10 shows estimated heights by century 900-1850. As can be seen within this period heights are largely trendless, despite estimates that English incomes per person nearly tripled between 1300 and 1800 (see figure 2 above). In particular heights in the 12th and 13th centuries were as great as those of 1800.[20]

The clear message from the height data is that there is no secular gain in heights in England all the way from 1100 to 1800.

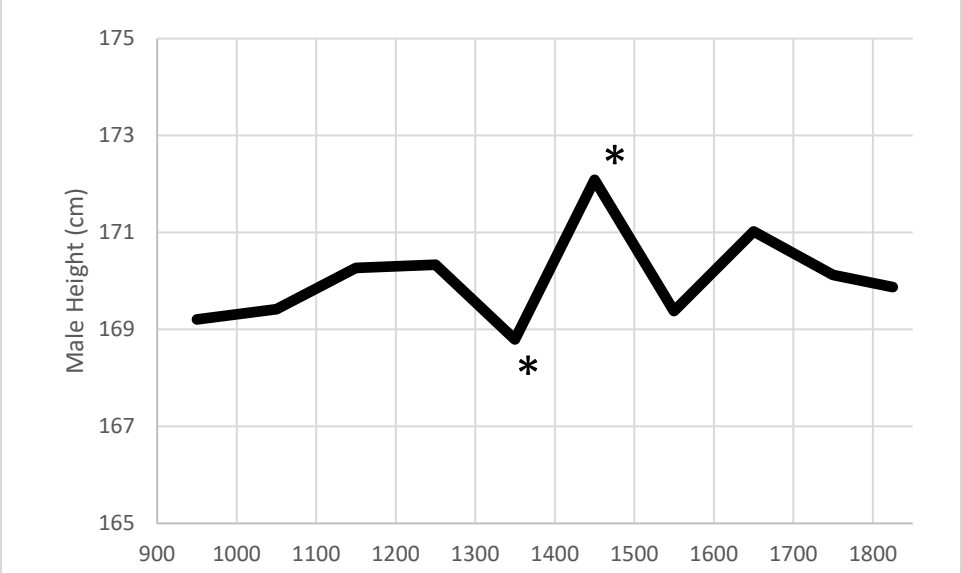
[20] These results differ somewhat from those of Galofré-Vilà et al., 2018, who estimate average heights in England from Roman times until the present. They report an even stronger finding of high stature in late medieval England, concluding "average heights reported between 1400 and 1700 were similar to those of the twentieth century." We have assembled a larger set of evidence for the medieval period than this alternative study utilized. But if we were to accept the Galofré-Vilà et al., 2018, estimates it would even more strongly indicate an absence of any secular gain in heights 1400-1800.

Table 6: Significant Coefficients in Height Estimation, 900-1850

Variable	Coefficient Estimate (cm)	Standard Error
Female	-12.015***	0.424
High Status Cemetery	1.107**	0.435
Deaths 1300-99	-1.431***	0.431
Deaths 1400-99	1.863***	0.581
Constant	170.225	0.441

Note: **Statistical significance 5%, ***statistical significance 1%

Figure 10: Average Male Heights by Century of Death, 900-1850



Note: * indicates significantly different from average height over the whole period.

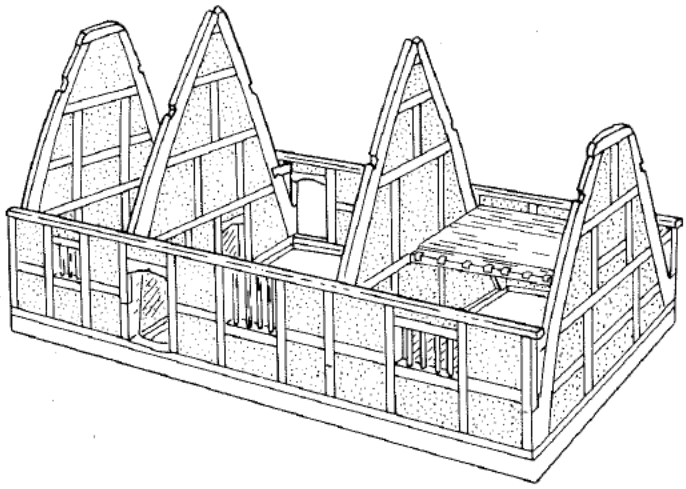
Housing

It used to be conventional wisdom for vernacular architectural history that none of the houses occupied by laborers or even modestly prosperous peasant farmers in medieval England had survived to the present time. The houses of this class of people in the Middle Ages were assumed to be impermanent structures, built of poor-quality materials scavenged locally, that needed constant repair. The absence of archeological evidence of these huts and hutlets was assumed to be because they had left no archeological trace in the 500 or so years since their abandonment. Only after 1570 was there a period of substantial building of more permanent rural structures which created cottages and houses that remained occupied to the present day (Catling, 2013). But even there it was assumed that the earlier of such structures which survived were those of the local gentry, with true peasant or laborer dwellings being found only from the late seventeenth century on.

However, in the last 20-30 years there has been a revolution in the field of vernacular architectural history brought about by the ability to precisely date the period of initial construction of some types of wooden housing using dendrochronology. These buildings are cruck-frame houses, where the basic frame in such housing is formed from pairs of timbers extending from the ground to the roof apex in a single truss arch. Typically these were houses with three bays, and four sets of trusses. The middle bay formed an open hall, without any upper floor or chimney. A sign that a house was originally of this type, even when later modifications added partitions and chimneys, is where the surviving roof timbers are covered in soot and tar deposits from smoke rising from the hearth located on the hall floor. One of the side bays was often used as a service space, such as a dairy, for example, while the other, the only one with an upper floor, provided sleeping spaces (Alcock and Miles, 2012). Figure 11 shows an example of such a cruck-frame dwelling, and figure 12 a surviving structure.

While other timbers in a house could be re-used from older structures, the trusses in cruck frame buildings were not likely to have been replaced or reused. They can thus be employed to estimate when the structure was originally built, and what the original floor area of the building was.

Figure 11: Schematic Illustration of a Cruck-Frame House



Source: Alcock and Miles, 2012, p. 5.

Figure 12: An Example of a Surviving Cruck-Frame House

Source: Old School Cottages, Wick, Worcestershire (Philip Halling)

A recent study initiated by the Bob Laxton, and continued by Nat Alcock, Robert Howard, Dan Miles, and Cliff Litton, set out to document all existing cruck-frame buildings in the West Midlands and determine the ages and dimension of the earliest such housing.[21] 83 cruck frame houses were found to have primary timbers suitable for carbon dating and dendrochronology. Nearly all the buildings tested were first constructed in the years 1260-1560, though mostly after 1350. Further these were on average very substantial structures. The average ground floor area was 881 square feet (82 m^2), and the total floored area 1,063 square feet (99 m^2) (Alcock and Miles, 2012, table 3.2, p. 33).

As noted, not all of this floor area would have been devoted to habitation. Since these houses were associated with farming, in the Middle Ages some of this space would have been utilized for animals, or for farm production activities. But in the modal structure of these houses, where there were 3 bays, typically no more than one would be devoted to such activities. That would leave at minimum 769 (71 m^2) square feet devoted to habitation: a central hall and a bay of bedroom space.

Could these all be surviving gentry housing, or housing just from the most prosperous of tenants? One form of evidence against this is that some villages contains many such cruck-frame dwellings. Long Crendon, in Buckingham, for example, has almost 30 such surviving dwellings, Steventon in Oxfordshire 15, Rothley in Leicestershire and Stoneleigh in Warwickshire 10.[22] There would be at maximum only 1-2 upper class dwellings in the typical medieval village, so in these villages the bulk of the medieval cruck-frame houses would be those of the peasantry.

A second evidence that these were the housing peasants of average status comes from the land holding associated with these houses in the fifteenth and early sixteenth centuries. These holdings were small enough to require only the labor of one man, so this housing was that of a householder whose income mainly derived from his own labor.

In Long Clendon and Steventon, for example, tracing the occupancy of these structures back through time using manor court rolls and other sources to the sixteenth and fifteenth centuries shows that these holdings incorporated typically only a yardland (24 acres) or less of land.[23] Bruce Campbell suggests that in the fifteenth century only 60% of arable land would

[21] Alcock and Miles, 2012.
[22] East Hendred and Harwell in Oxfordshire also had significant numbers of such cruck-frame dwellings.
[23] See Alcock and Miles, 2012, pp. 125.

be sown each year (Broadberry et al., 2015, table 2.10, p. 74). Thus, each of these houses would be in a holding with 14.4 sown acres or less. But in the fifteenth century one man in five weeks could harvest 16 acres, based on observed work rates (Clark, 2018, table 2). So the typical holding associated with these surviving medieval houses would only require the labor of one family. They would indeed be genuine peasant households with little or no hired labor.

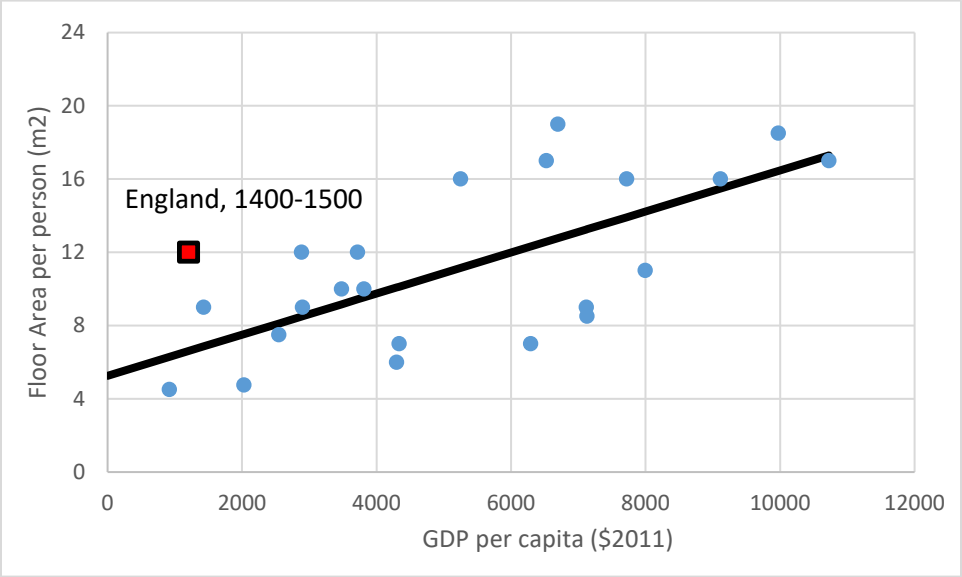
Stoneleigh in Warwickshire reveals similar patterns of modest land areas in the holdings associated with the houses. Holdings at Stoneleigh were even smaller on average than Steventon or Long Crendon. Two of the houses held two yardlands, but the other eight had only an acre or two. The average floor area at Stoneleigh matches the overall average of 850 square feet for cruck-frame houses in the Alcock and Miles survey. A survey of probate inventories for Stoneleigh between 1532 and 1560 further confirms this picture of modest land holdings, with the majority of inventories listing individual's land holdings then as a yardland or below.[24]

In this case we can assume the bulk of the surviving medieval housing surveyed by Alcock and Miles were originally single family habitations, for families that lay in the middle of the social spectrum. Assuming an average family of 5, this implies 154 square feet per person, about 14 m^2 There were also in these villages smaller cottages in the 14^{th}-16^{th} centuries, occupied by tenants who worked the land held by the manor or the largest peasants. But in Long Crendon the demesne land was only about a third of the total. So even if a third of the families lived in more modest and impermanent cottages with only half the floor area of the cruck dwellings, average floor area per person would still be 128 square feet per person, about 12 m^2.

How does this compare to housing space per person in the modern world? Figure 13 shows floor space per person in 1993 in a set of major cities in poorer countries of the world, graphed according to GDP per capita in 1991 (in $2011). England is shown with its GDP per person in the same units as estimated for 1400-1500 by Broadberry et al., 2015. As can be seen the implied floor area per person is about double what we would expect from the modern connection between floor area and output per person.

[24] Alcock and Miles (2012), 146-7. The authors point out that there is no correlation between the size of a house and the economic status of its occupants in the probate inventories. Four room houses are the most common in the inventories and they are associated with holdings between 3 and 71 acres.

Figure 13: Floor Space per person versus GDP per capita, 1993



Source: Floor Space - United Nations Centre for Human Settlements (HABITAT), 1996, figure 6.2, p. 206. Income per capita in 1991, Feenstra et al., 2011.

Interestingly, in Long Crendon as population increased in the eighteenth century the medieval cruck houses were increasingly subdivided to make more modest sized dwellings. By the early nineteenth century at least a third of the medieval cruck houses had been divided into 2-3 dwellings. Also by then the vast majority of houses in the village, at least 80%, were such smaller cottages (Alcock and Miles, 2012, 126-7). So floor space per person declined between the 15th century and 1800, despite the claim that incomes per person in England nearly doubled in this interval.

Once again there is a disconnect between the extremely low incomes estimated for pre-industrial England and other evidence about living standards in Medieval England.

Days Worked per Year and the Labor Share in Farm Costs

The assumption that days worked per year was as low as 100 in 1400 creates impossible accounting problems in terms of the medieval agrarian economy. For any sector of the economy there is an important accounting identity. The value of the output has to sum to the payments to the factors cooperating in production. Specifically for medieval agriculture we must have

Output value per acre = rent per acre + tithe + working capital expenses + labor payments

We can estimate the various elements of this identity for England 1270-1450. The output value per acre, net of seed, is derived from Broadberry et al., 2015.[25] Rental payments per acre are derived by Clark, 2016, table 3. Tithe is assumed to be ten percent of the value of output. Working capital expenses are the implicit capital rental returns on the working capital in farming: animals, equipment, payments in advance of sales. These are hard to estimate, and are derived using the rates of return on capital from investments in land and rent charges estimated in Clark, 2016, table 5, as well as an assumption that the amount of working capital per unit of output was the same as in the nineteenth century.

For labor payments we have good estimates on day wages (Clark, 2007). But we need to also estimate the numbers of acres per worker, and the number of days each of those workers was employed. To estimate the number of acres per worker we assume that each worker was fully employed, six days per week, for the five weeks of the harvest season. The justification for this assumption is in part that throughout the period 1270-1450 harvest wages rose just as much compared to out of harvest wages as they did in England 1800-1869, when we know workers worked a full harvest season (Clark, 2018, figure 2). But also the medieval harvest period saw substantial numbers of women drawn into reaping alongside men.[26] So there is every indication that all the labor force was employed, at least at harvest. Harvesting was paid for both through day wages, but also through payments per acre of grain reaped, all through 1270-1450. So we can get estimates of how many man-days were required per acre of each type of grain, by period.

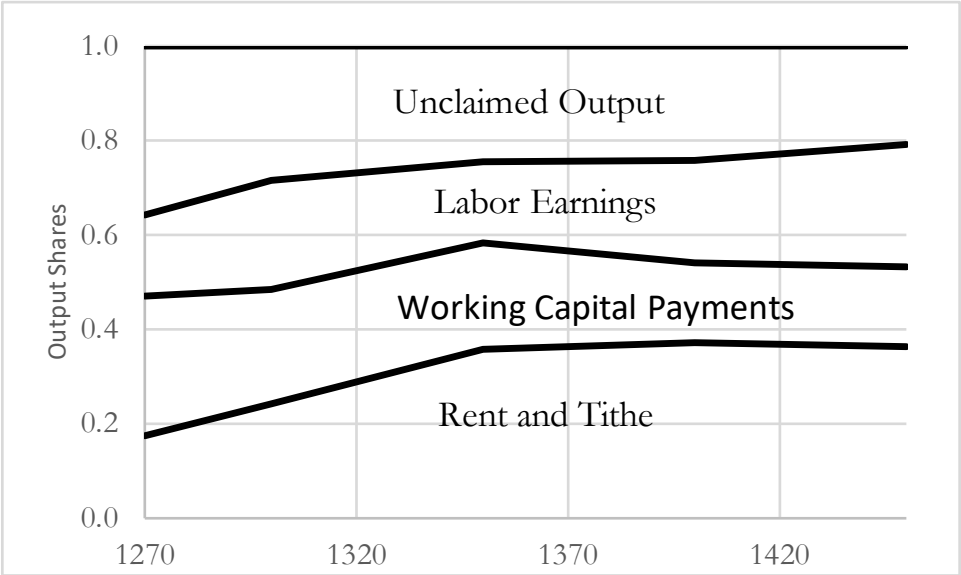
[25] Broadberry et al., 2015, tables 3.03, 3.06, 3.07, and 3.17 (pp. 88, 96-7, 114).
[26] Heavier winter activities such as threshing, manuring, ditching and hedging were exclusively carried out by men.

Thus, we can get an estimate of how many sown acres there would be per male worker throughout the interval 1270-1450, and from the distribution of land use, how many acres overall per worker. These numbers seem very reasonable, in light of other evidence. Thus, for the years before the Black Death onset of 1348-9 the estimated number of acres per man is around 20, while by 1400-1450 it is almost 40. The typical size of medieval peasant holdings, at least in midlands England, before the Black Death was in the range 20-30 acres of land (a virgate or yardland), fitting with the idea that this was the amount of land a family could cultivate. The increase in land per worker after the Black Death was associated with a smaller share of the land being used for arable, and with workers harvesting more acres of grain per day (in part because grain yields per acre then were lower than before the Black Death).

For the number of days per worker let us take the numbers suggested by Humphries and Weisdorf (figure 5 above), which are broadly in line with the numbers of days per worker suggested by Broadberry et al., 2015. We can then estimate total implied labor payments per acre, assuming each male worker works 30 days at the higher harvest rate, and the remaining days at the out of harvest wage. On the Humphries and Weisdorf estimates this implies in some periods only around 70 days of paid labor per worker.

These numbers are put together in figure 14, which estimates the implied share of output that is collected as rent and tithe, capital payments, and labor earnings. Two things are notable. The first is the very small share of output that goes to labor earnings. On average only 21% of output goes to labor. The share of labor payments in English agriculture in contrast in the nineteenth century was about double, at 40%. Also since agriculture was the major activity of the English economy, at least before 1349, this would imply a surprisingly small share of total output going to labor in the economy as a whole. The second notable element is the large share of output which was seemingly unclaimed by either landowners, farmers, or the laborers. We do not believe farming was ever characterized by supernormal profits for farm operators. The farm operators themselves do not seem to have been the recipients of this bounty. But here there is on average 27% of output unclaimed, more than a quarter. This cannot happen.

Figure 14: Factor Shares in English Agriculture, 1270-1450



Source: See Text.

Some of these estimates are subject to substantial margins of error, though the estimated output per acre and payments to labor are relatively good.[27] Thus, the conclusion that under assumptions of only 100 days labor per worker in 1350-1450 the labor share in output would be only 20% is relatively firm. The capital share and rent share are harder to estimate. But there is no reason to expect they could be misestimated enough to substantially close this output gap.

The most plausible explanation for this puzzle of unclaimed output is that the days worked per year per worker were much greater than the proponents of significant growth have had to posit. The 100 day work year of 1350-1500 is a fiction, with actual work years at least in the 200-250 days per year range.

[27] Output per acre is estimated for the manorial sector only, but there is no reason to believe this differed greatly from the peasant economy.

Conclusion

Reported day wages in England before 1800 suggest that there was little, if any, growth of output per worker between 1209, when reliable wage data first appears, and 1800. The proponents of a breakaway from the Malthusian era much earlier than 1800, in the late medieval era around 1300, have thus had to posit major increases in days worked 1300-1800. They seemed to find recent support in the estimates of Humphries and Weisdorf, 2019, of a work year in 1350-1500 of as little as 100 days per year, based on the ratio of annual wages to day wages.

Note, however, that James Thorold Rogers, the great quantitative historian of the nineteenth century who in 1884 in *Six Centuries of Work and Wages: The History of English Labour* proclaimed the fifteenth century as "the golden age of the English laborer."[28] Rogers noted as an example the craftsmen at York Minster who were paid an average of 149 shillings a year in 1415. At the conventional wage of craftsmen of 6 d. per day this amounts to 297 days of work on average. Similarly at Windsor in 1408 the King was paying carpenters 5.4 d. per day on average, for all 365 days of the year. If these workers were putting in only a 100 day work year, then their effective wage per day would be 20d. per day, more than three times the typical wage for carpenters. These 365 days of payment at this rate only make sense relative to workers hired by the day if the King's workers were working typically at least 5-6 days per week.[29]

Above we show the implausibility of a picture of England pre-1540 as substantially poorer than in 1800 using a variety of means. Medieval workers fed on the job, 1350-1550 received a food ration that was greater than for workers 1600-1834. The diet of the medieval era had large amounts of meat, fish and dairy products, as revealed by the importance of butchers and fishmongers as a share of retailing occupations, the absolute numbers of butchers and fishmongers per head of population, and the bones of the medieval English having high levels of the ^{15}N isotope that is abundant for those eating an animal-based diet. The Medieval English were tall for pre-industrial populations, with no significant upward trend in heights 900-1800. The dwellings English peasants lived in were sturdy structures, some of which survive to the present day, with substantial amounts of floor space per person, at least in the period 1400 and later. The floor space they occupied is now associated with societies with incomes at least twice what Broadberry et al., 2015, estimate for England 1400-1550. And finally the value of output per worker in medieval agriculture was so high that workers must

[28] Thorold Rogers*, 1884, p. 325.*
[29] Ibid., p. 327.

have been working many days per year, since payments to other factors account for no more than half of the value of farm output.

England of the early 13th century, and of the 15th century was a rich society even by the standards of 1800.

Appendix: Day wages without and with food, 1355-1834

This appendix details the sources for day wages with and without food (and sometimes lodging) in table 1. From this we can infer the share of feeding costs in the day wage. For the wage assessments 1563-1732, and for 1770-1834 these are all day wages of farm laborers. For the years 1355-1603 the observations include farm laborers, laborers, and craftsmen. This should bias the estimated food share in day wages downwards in Table 1 for these observations compared to observations on farm workers alone, because of the higher wages of craftsmen. The cost of food per day is estimated as the average farm day wage by period times this food share in day wages.

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These were assessments by local magistrates of the maximum wages of different categories of workers for that year. A typical statement would be this example from Exeter 1588 "..husbandry labourers out of the time of corn harvest shall not take by the day with meat and drink… above 3 d., and without meat and drink 6 d." Since these assessments were frequently reissued without change, where there was data for a run of years with rates unchanged, we only employed those for the first year of the run.

The assessments included are Northamptonshire, 1560, Berkshire 1563, Kent (Maidstone), 1563, Kent, 1563, Lincoln, 1563, Yorkshire East Riding, 1563, Northamptonshire, 1566, Yorkshire East Riding, 1570, Kent, 1576, Essex, 1583, Devon 1588, Hertfordshire, 1591, Yorkshire East Riding, 1593, Devon, 1595, Hampshire, 1595, Lancashire, 1595, Wiltshire (New Sarum), 1595, Merioneth, 1601, Wiltshire, 1603, Norfolk, 1610, Rutland, 1610, Lincoln, 1621, Suffolk, 1630, Gloucester, 1632, Hereford, 1632, Hereford, 1632, Dorset, 1633, Derby, 1634, Wiltshire, 1635, Yorkshire West Riding, 1647, Essex, 1651, Gloucester, 1655, Wiltshire, 1655, Yorkshire North Riding, 1658, Essex, 1661, Worcester, 1663, Middlesex, 1665, Somerset, 1665, Northamptonshire, 1667, Lincoln, 1668, Yorkshire East Riding, 1669, Bedford, 1684, Warwick, 1684, Somerset, 1685, Wiltshire, 1685, Kent, 1724, Shropshire, 1732

(Hughes and Larkin, 1969a, 1969b, Thorold Rogers, 1888b, 694-97 Thorold Rogers, 1888c, 685-700, Le Hardy, 1900, 400-04, Cox, 1890, 239-42, Putnam, 1927, 131-2, Historical Manuscripts Commission, 1888, Historical Manuscripts Commission, 1901, 162-75, 323, Historical Manuscripts Commission, 1894, 31, Cunningham, 1903, 888-893, Willan, 1947, Trotter, 1919, 161-2, Somerset Record Society, 1919, 13, Roberts, 1856, 207-9, Page, 1914, 227-31, Davies, 1813, 500-1).

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