

Continuity and Change in Hertfordshire Agriculture 1550-1700: II – Trends in crop yields and their determinants

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Abstract

Using a version of a method developed by Overton, data from probate inventories are used to identify periods of increasing land productivity in early modern Hertfordshire. Some of the factors which may underlie higher crop yields are discussed. It is suggested that increasingly systematic ground preparation prior to sowing was a major factor increasing land productivity. The chronological and geographical patterns of higher yields were similar to those of recorded valuations of ground preparation. A concluding discussion investigates possible changes in patterns of farm investment.

THIS paper is the second of two essays discussing agricultural change in the county of Hertfordshire in south-east England. Its partner, in the previous issue, dealt with aspects of agricultural production and their geography. This paper tackles the difficult topics of trends in crop yields, of how yields may have been raised, and of farmers' attitudes to agricultural investment.

Since the discussion involves many detailed stages and qualifications, it may be helpful to outline the argument advanced. In section I, I argue that substantial yield increases for wheat, barley and oats were achieved by farmers in Hertfordshire during the later seventeenth century. The absolute level of yields remains uncertain, but it is likely that yield increases during the eighteenth century were relatively modest. In section II, the yield increases are shown to pre-date the widespread introduction of new fodder crops. Instead, more systematic preparation of ground prior to sowing (both to raise soil fertility and to improve moisture retention on light soils) is suggested as an important contributory factor, although some other factors influencing yield cannot be investigated using inventory data. In section III, the geography of 'high-yield' farms is examined, and shown to coincide with areas in which ground preparation was

most frequently evident. The wider context of the changes identified is discussed in section IV, which suggests that farmers' attitudes to investment were changing, and argues that shifts in relative prices provide a poor guide to farmers' incomes at times of productivity change.

I

It is probably fair to say that yields per acre and productivity per man are the two great unknowns of early modern agriculture; the keys that more than any others might move us closer to an understanding of English agrarian development. Unfortunately, there are no sources which directly record agricultural yields on a wide scale prior to Governmental interest around the turn of the eighteenth century, leaving a long gap from the major medieval source of yield data, the manorial account.¹

Recent work, summarized in Table 1, indicates that in c.1800 yields in Hertfordshire were above average by contemporary

¹ It must be recognized that knowledge of medieval yield trends is restricted to a few areas and estates: J Z Titow, *Winchester Yields: A Study in Medieval Agricultural Productivity*, Cambridge, 1972; D L Farmer, 'Grain yields on the Winchester manors in the later middle ages', *Econ Hist Rev* 2nd ser XXX, 1977, pp 555-66; D L Farmer, 'Grain yields on Westminster Abbey manors, 1271-1410', *Canadian Journal of History/Annales Canadiennes d'Histoire*, 18, 1983, pp 331-48; B M S Campbell, 'Agricultural productivity in medieval England: some evidence from eastern Norfolk', *Jnl Econ Hist* 43, 1983, pp 379-404.

TABLE 1
Yields in Hertfordshire, c.1794-c.1836

	Wheat	Barley	Oats
1790s average	20	30.5	28.5
1794	19	24.5	22
1795	15	31.5	30.5
1800 average	20-24	32-40	31-36
1801	25	34	—
1836 average	21.6	29.4	33.6

Yields as percentage of estimated national averages

	Wheat	Barley	Oats
1790s average	103	111	105
1794	113	110	102
1795	96	111	107
1800 average	91-110	117	98
1801	111	113	—
1836 average	100	96	96

Sources: Calculated from: M Turner 'Agricultural productivity in England in the eighteenth century: evidence from crop yields' *Econ Hist Rev* 2nd ser, xxxv, 1982, 492-510; E J Connell 'Hertfordshire agriculture during the Napoleonic wars' *Hertfordshire's Past*, 10, 1970, 22-35; R Kain *An Atlas and Index of the Tithe Files of mid-nineteenth-century England and Wales* Cambridge, 1986, unweighted county averages.

English standards.² Wheat yields were about 10 per cent above average yields notified to the two House of Lords Committees on the Dearth of Provisions in 1795 and 1800, and as stated in the Crop Returns of 1801, although the small number of parishes with extant data means that these results should be treated with some caution. The tithe agreements in the 1830s produced very similar yield estimates,³ and so there is little sign that productivity per acre increased in the first third of the nineteenth century. Average yields increased elsewhere during this period, and

² M Turner, 'Agricultural productivity in England in the eighteenth century: evidence from crop yields', *Econ Hist Rev* 2nd series, XXXV, 1982, pp 489-510.

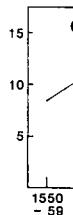
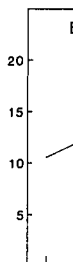
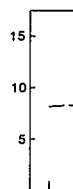
³ R Kain, *An Atlas and Index of the Tithe Files of Mid-Nineteenth-Century England and Wales*, Cambridge, 1986.

wheat yields in Hertfordshire were thus no longer above the English average. Much the same was true for barley and oats. Since these average yields are considerably higher than those of the most productive medieval estates, the question arises as to when exactly yield increases had been achieved.

At best, yield and productivity changes can only be estimated indirectly from sources such as inventories. A major new approach to this intractable topic has been originated by Overton and developed by Allen (outlined in Appendix 1).⁴ Put simply, Overton estimates yield trends from the relationship between valuations per acre of grain growing shortly before harvesting and valuations per bushel of grain in store after harvesting. In valuing standing grain, appraisers were estimating two things, the likely yield (quantity of grain per acre) and the likely selling price per unit quantity. Any estimate of valuation per acre implies one of a number of particular combinations of these two variables. By treating the estimated sale price and the value of grain after the harvest as equivalent, the average valuation per acre of growing grain can then be expressed in terms of bushels. In applying this method, I follow Allen's modification and treat years independently rather than combining valuations from several years as Overton did (see Appendix 1). However I have also calculated results using Overton's original method for purposes of comparison.

⁴ M Overton, 'Estimating crop yields from probate inventories: an example from East Anglia, 1585-1730', *Jnl Econ Hist* 39, 1979, pp 363-78. Bob Allen of the University of British Columbia suggests methodological modifications and makes criticisms of Overton's interpretation of results in R C Allen 'Inferring yields from probate inventories' *Jnl Econ Hist* 48, 1988, pp 117-125. I am very grateful to Dr Allen for a draft copy of the paper. A comparison of the results produced with and without certain of Allen's modifications to Overton's method may be found in Appendix 1. Recent attempts to infer productivity changes via the use of patent data and agricultural publishing to determine 'periods of inventiveness and innovation' have not been convincing. R J Sullivan, 'Measurement of English farming technological change, 1523-1900', *Explorations in Economic History*, 21, 1984, pp 270-89; R J Sullivan, 'The timing and pattern of technological development in English agriculture, 1611-1850', *Jnl Econ Hist*, 45, 1985, pp 305-14.

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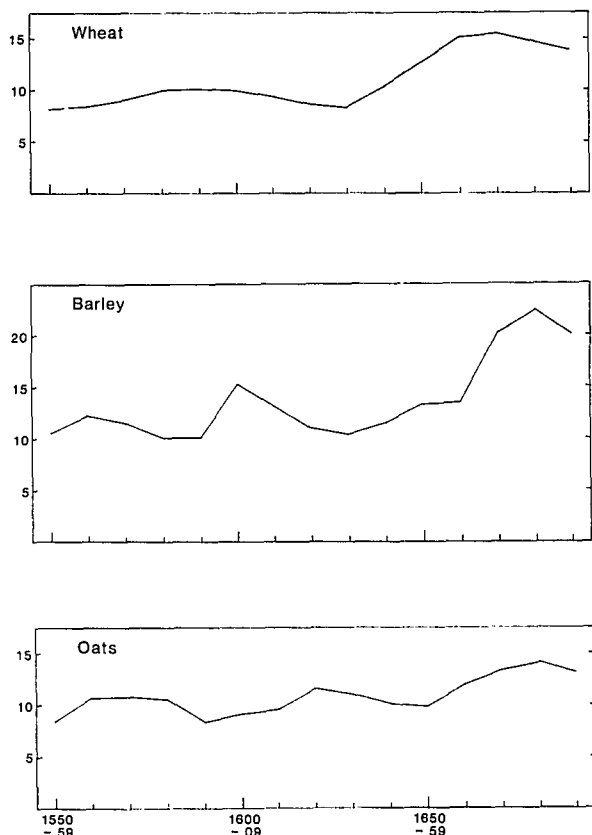


FIGURE 1

Trends in mean valuation per acre of cereal crops.

Note: The cash valuation for standing grain has been divided by the average valuation of the relevant grain from post-harvest inventories of the same year. Only inventories from July and later have been used. Inventories in which grain is valued at the perceived costs of production rather than the likely worth to the heir have been excluded.

Results obtained by this method are clearly not estimates of yield per acre as such, since valuations of growing crops are net of presumed or estimated harvesting costs, and of tithes to which crops were liable. 'Yields' thus estimated are, more correctly, 'bushel equivalents of valuations per acre'.

Bushel equivalents of average valuations per acre for wheat, barley and oats, based on a total of about 800 inventories are shown in Figure 1. Not only are these valuations per acre not yields as such, since they include allowances for the perceived costs of harvesting and tithes, but both valuations per acre and valuations per bushel presumably include an allowance for the cost of transporting grain to market. How this was calculated we do not know. However, since valuations per bushel bear a reasonably consistent relation to market prices these estimates should establish trends in appraisers' predictions of yields.

Prior to interpreting these trends it should be recognized that while the total number of inventories is quite large, they stretch over a 150-year period, and there are still several years for which any inventory valuations for growing or stored grain are lacking. For several other years, the number of suitable inventories available is small, and the estimates for these years may be subject to wide margins of error. This is true mainly of the early decades for each series and for the 1650s.⁵

In Figure 1 a three-decade moving average has been used to smooth the series in order to draw attention to the long-term changes. All three series have two major points in common. First, yields towards the middle of the seventeenth century were no higher than in the 1560s and 1570s. Secondly sustained increases occurred from the 1660s or 1670s, and these were on a scale and of a substantial nature which was different in kind from the shallower or more short-lived upward fluctuations observable in the century or so before about 1650.

⁵ Since this study used only inventories which contained an occupational designation, the sample of inventories could be enlarged by utilizing inventories which do not specify the occupation of the deceased.

Before accepting that these were genuine yield increases, at least three possible explanations need to be considered. First, the representativeness of the inventory sample may have changed. For example, if yields and the size of farms were positively related, then the effect of land becoming concentrated in the hands of larger farmers would be higher mean yields. This would not imply that any particular group of farmers was achieving higher yields through innovations in crops or techniques. While this scenario is a plausible one for the late seventeenth century, the scale of yield increases evident from Figure 1 are so large that differences in productivity with farm size cannot have produced more than a small proportion of that increase.

A second factor likely to influence average yields is the extent of the cultivated area. All other things being equal, average yields should vary inversely with the conversion of pasture land to arable, as land that was marginal for arable cultivation moved from one sector to the other. It might be expected that at times when price relatives were moving towards pasture (such as after 1650) average yields would rise as the poorest arable land was converted to permanent pasture.⁶ However, the pattern of farm specialization (Table 2) indicated that any arable to pasture switch across the county as a whole was on a very modest scale and is thus unlikely to have been a significant factor in producing higher yields.⁷ Even if large-scale changes in land use had occurred, though, it is implausible that differences in land quality alone could explain more than a small part

of the increases graphed in Figure 1.

It is more difficult to be sure that the changes in yield estimates found were not the result of some change in the appraising conventions which the compilers of inventories applied when they viewed growing crops. We lack other documentation which might allow us to cross-check the process of appraising against the items listed in inventories. However on the internal evidence of the appearance and contents of inventories through time, such a change appears unlikely. There was no change in the legal requirements relating to the duties of appraisers or methods of valuing. There is no detectable change in the way of valuing grain in store, which continues to correlate with market prices. The pattern in which livestock and other farm equipment were valued does not appear to have changed. In short for this explanation to account for the estimated yield increases, we would be required to accept that a change in the conventions regarding the appraising of growing crops, but no other component of farms, had taken place. Furthermore we should have to accept that such a change had no legal basis and yet occurred over the wide geographical area in which farms with significantly above average valuations of grain per acre were to be found. Such an explanation is highly implausible.

It therefore seems that these results do indicate a genuine increase in arable yields. As was suggested above, a critical stage in interpreting these results comes in estimating absolute actual yields: the gross yield rather than the yield net of harvesting costs, transport, tithes and so on, which is what is plotted in Figure 1. Obviously the degree to which we inflate the net yield series to compensate for these costs will affect the relative importance of the seventeenth and eighteenth century as periods

⁶ A short-term exception to this would be where permanent pasture is ploughed up for arable. Here, yields are likely to be raised in the short term as arable crops make use of the nutrients stored in the soil and not used by the grass.

⁷ *Ag Hist Rev*, 36, p 69.

TABLE 2
Characteristics of two groups of farms in the 1690s

	<i>Inventories with prepared ground (n=33)</i>	<i>Inventories of other active farmers (n=96)</i>
<i>Mean farm (crops + stock)</i>		
for yeomen	380 (19)	122 (49)
for husbandmen	234 (14)	43 (47)
<i>Mean valuation (£)</i>		
of crops	230	82
of livestock	88	40
of farm equipment	28	14
<i>Percent possessing</i>		
horses	94	72
cattle	97	76
sheep	88	65
hogs/pigs	85	64
<i>Percent growing</i>		
clover or other new grass- substitutes	28	7

of agricultural progress.⁸ For example, if we guess that the appraisers of inventories reduced the gross value of crops by about 20 per cent to allow for total harvesting costs (and tithes), then there is still room for significant, though not dramatic, yield increases in the eighteenth century to reach the yields recorded in c 1800. On the other hand, if appraisers allowed say 35-40 per cent for total harvesting costs (and tithes), then gross wheat and barley yields in Hertfordshire in the 1680s were as high as they were in 1801.

I would regard the lower figure as the more plausible, but this cannot be demonstrated. It should be noted, though, that the key question here is not what the actual

costs of harvesting were (although these can be estimated from some farm accounts), but how appraisers took these costs into account in making valuations. For example, if some of the labour involved in harvesting was provided by farm servants rather than hired wage labour, then the labour costs relating specifically to harvesting would be quite low, since the maintenance of servants was a one-off fixed cost for the year, not a variable cost depending on the performance of particular tasks. In this context it is notable that Kussmaul identifies a significant growth in the incidence of farm service in southern and eastern England in the later seventeenth century.⁹

II

Many factors affect output per acre. Until comparatively recently it was almost axiomatic that sustained yield increases in early modern agriculture occurred only after the widespread introduction of new fodder crops such as turnips, clover and other

⁸ It is in part a failure to appreciate this point that has led to the disagreement between Turner and Overton concerning crop yields in the eighteenth century: Turner, 'Agricultural productivity'; M Overton, 'Agricultural productivity in eighteenth-century England: some further speculations', *Econ Hist Rev* 2nd series XXXVII, 1984, pp 244-51; M Turner 'Agricultural productivity in eighteenth-century England', *Ibid.*, pp 252-7. Turner's comment (1984, p 257) that 'between Overton's inventory data of the 1730s and Arthur Young's visitation of the 1760s something extraordinary seems to have happened down on the farm in East Anglia' takes no account of the fact that Overton's estimates are of 'yield' net of tithes, harvesting and possibly some other costs, while Young's estimates were of gross yield.

⁹ A Kussmaul, *Servants in Husbandry in Early Modern England*, Cambridge, 1981, pp 97-119.

new grasses. However it seems highly unlikely that the appearance of new grasses and root crops has a significant role to play in explaining how these higher arable yields were achieved. First, the widespread occurrence of either type of new crops in inventories substantially post-dates the yield increases, and so cannot logically explain them. Secondly, while clover and other new 'mowing grasses' were more common than turnips and other root crops, they appeared in barely 10 per cent of farmers' inventories by the end of the seventeenth century. Even if we allow for the likelihood that new crops appear in inventories at a lag of some years after their introduction, they still appeared in numbers and quantities too small for them reasonably to be invoked to explain the yield increases of Figure 1.

A possible cause of higher yields is hinted at by one of the most persistent observations made by contemporary commentators such as Ellis, Walker and Young.¹⁰ While Young found little to admire about agriculture in Hertfordshire, he and other writers were unanimous in commending the high level of dunging and other fertilization, and the range of techniques involved in its application and in the preparation of soil for crops. 'It will be apparent', wrote Young, 'that manuring alone must occasion a disproportion so very great between the soil and the crops; the latter being so very superior to the soil.' In saying this, Young was essentially echoing the comments of his predecessors through the eighteenth century.¹¹ Elsewhere he says that most progressive agricultural methods were known in the

county in Ellis's day, which may imply limited progress between the 1730s and 1790s.¹²

All these commentators list a wide range of substances applied to soil. The general term 'ground preparation' is an appropriate label because applications were made for diverse purposes. Many substances were applied to raise fertility, but other techniques, such as the ploughing in of shredded rags, were primarily directed to increasing the capacity of light soils to retain moisture. One way of approaching the question of how effective was the use of manure, marl, chalk and other substances applied to arable land is the appearance in increasing numbers of inventory valuations relating to the preparation of ground for crops. While these entries are not always as explicit as we might like, a number of examples will help to illustrate their style, and hint at the sort of activities which lie behind less informative entries.

One of the earliest inventories to make explicit what was involved in ground preparation is that of the quaintly named Affabell Battle, yeoman of Tewin, from 1630.¹³ His total estate of over £1000 included nearly £700 of farm produce and equipment, amongst which was £42 17s 0d 'for dunging and chalking and fallowing and stirring of ground'. The Christian name Affabell perhaps suggests a Puritan background, but there is little indication that Puritanism and this sort of 'agricultural investment' were particularly related: few such inventories were those of men with overtly Puritan Christian names. At the end of the century and on the other side of the county at Great Gaddesden, Henry Tudder's inventory of nearly £200 included £10 for 'fallowing, stirring, dunging and dressing' land in readiness for crops.¹⁴ At

¹⁰ W Ellis, *Chiltern and Vale Farming*, 1732; W Ellis, *The Practical Farmer, or Hertfordshire Husbandman*, 1732; W Ellis, *The Modern Husbandman*, 1744; D Walker, *A General View of the Agriculture of Hertfordshire*, 1795; A Young, *A General View of the Agriculture of Hertfordshire*, 1804, reprinted Newton Abbot, 1971.

¹¹ Young, *op cit* pp 157-8: 'There is no part of the kingdom in which this branch of husbandry ... is more generally attended to; or where exertions in it are more spirited'. Walker had commented that 'top dressing is the leading feature of Hertfordshire farming' *op cit*, p 40.

¹² Young, *op cit* p 55: 'this appears from the writings of Ellis, ... There are at present scarcely any practices to be met with in the county, that were not well understood at that period'.

¹³ HCRO 10/HW/23.

¹⁴ HCRO H23/2388.

about the same time at Hitchin, John Everard's appraisers were allowing £7 'for the composting laid on the land hired by him which is to be tilled for barley'.¹⁵ Finally, the most detailed account of all comes from the inventory of John Kirby of Ardleigh in 1695,¹⁶ where preparation for crops contributed nearly £40 to an inventory of about £240. Unusually his appraisers listed and valued various components of this valuation separately. Presumably from a notebook or farm accounts, they enumerated:

£29 for 29 acres of land ploughed four times,
£2 14s for the dung carted at 6s a day for nine days,
£1 10s for the application and the stirring of the dung,
£6 for the folding of nine acres at 13s 4d an acre,
4s 6d for the spreading of nine acres of dung there.

Although they are rare, valuations like these are not unknown in the late sixteenth century, but through the seventeenth century the proportion of inventories with them grew fairly rapidly (Figure 2). Of the 156 inventories which specify valuations ground prepared for crops, more than half occur after 1660. Their frequency varied among status groups, being commoner among yeomen than those designated husbandman, and only occasionally being mentioned in the inventories of labourers, or of craftsmen and tradesmen.

The figures themselves may be underestimates of the frequency of the technique, since they are based on inventories from all times of the year, whereas the frequency of recording varied slightly over the year. Taking the period 1610-1699 as a whole, a disproportionately high number of mentions of prepared ground occurred in inventories appraised between August and January. There were 27 per cent more mentions of prepared ground in these autumnal and winter inventories than there would have been if inventories mentioning prepared ground had been evenly distributed throughout the year. Whilst this is a less strongly seasonal pattern than affects

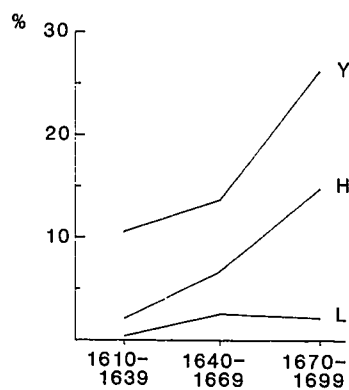
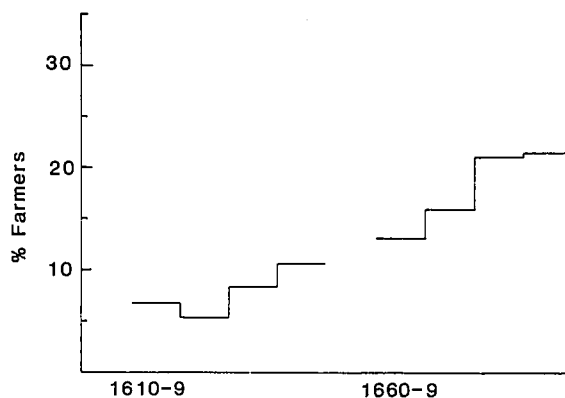


FIGURE 2

Trends in the percentage of farmers' inventories in which ground preparation is recorded.

Note: In the lower graph, Y = Yeoman, H = Husbandmen, L = Labourers. Labourers are not included in the upper graph.

some other aspects of farming (such as the mention of particular crops), it is likely to reflect the seasonality of the underlying activity. It may therefore be appropriate to inflate the figures in Figure 2 by about 25 per cent to obtain a more accurate estimate of the frequency of major ground preparation activity amongst farmers. Naturally this increases the apparent rate of diffusion of the innovation among the farming population.

The increase of references to ground preparation may reflect the growing tendency for leases explicitly or tacitly to specify a range of obligatory cultivation practices to tenants.¹⁷ Whether such ground

¹⁵ HCRO 38/HW/11.

¹⁶ HCRO 76/HW/27.

¹⁷ Highlighted by C. Clay, 'Landlords and estate management in England', *AHEH* V, II, pp 119-251, especially pp 214-24.

preparation predominantly reflected landlord influence, or the enthusiasm or desperation of tenants, is an open question. However, there is no doubting its proliferation, and I believe that this represented a significant intensification of farming systems. It is possible that increasing ground preparation provides an example of the application in agriculture of lessons learned in horticulture. Unless the inventory evidence is totally misleading, the attention to soil preparation, which later so impressed Ellis, Walker and Young, was one of the major developments in seventeenth-century agriculture in this area.

III

Overton's method of estimating yields from inventory valuations produces estimates of yields at an aggregate level for the whole body of farmers' inventories. He does not attempt to estimate yields for individual farms. Such knowledge would be very desirable since yields on particular farms could then be related to other characteristics of farms, shedding light on hypothesised causes of yield changes and variations. Overton's reservations over attempting to estimate yields for individual farms reflect the impossibility of distinguishing, from inventories themselves, between variations in valuations per acre due to higher yields and variations in valuations per acre resulting from the dispersal of 'estimation errors' about the mean valuation per acre. This difficulty is particularly acute when only relatively few inventories provide sufficiently detailed valuations in a given year. Thus a simple map of farms on which valuations per acre of a crop were high relative to the average for that crop in that year would include both farms on which yields were high and unit valuations average, and farms on which yields were average and estimates of standing crop quantity were at the high end of the distribution.

The following section should therefore be regarded as an experiment as to whether analyses based on estimated yields for single farms will produce meaningful results. For each farm in the periods 1610-1649 and 1660-1699, I have divided the valuation per acre of each of wheat, barley and oats by the average per bushel valuation of that grain in all late summer/autumn inventories from that year. From each year I have identified the inventories containing the highest per acre valuations of each crop, provided that two criteria are met. The first is that there are at least six relevant inventories for that crop in that year, and the second is that this highest valuation per acre is at least 25 per cent above the average valuation per acre. Thus a maximum of three farms (one for each crop) could be selected by this procedure for each year. In practice the number of relevant farms is lower, because of a shortage of sufficiently detailed inventories (especially for barley before 1649 and for oats throughout), or because the highest per acre valuation was less than 25 per cent above the mean for the crop in that year. While more 'high yield' farms could be picked out using a lower threshold, it would be more likely that they owed high valuations to inadvertent over-estimates of quantities of standing grain by appraisers.

Figure 3 indicates the locations of farms thus selected. Data are too sparse to sustain

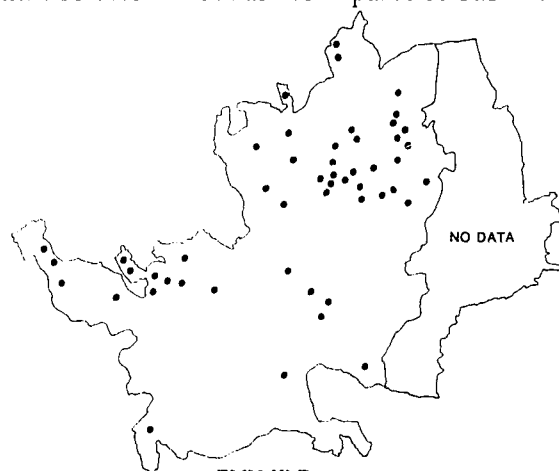


FIGURE 3
Location of inventories with the highest valuations per acre of growing crops, 1660-1699.

a detailed discussion for the period before the 1660s, but the pattern thenceforth, when crop yields appear to have been rising, is of great interest.¹⁸ There is a striking concentration of high valuations of growing crops in two areas. The larger concentration lies in the central northern part of the county running from the Waldens, Hitchin and Stevenage in the west to the Mundens, Cottered and Rushden in the east, with a second area in the extreme west, stretching from Tring eastwards to the Gaddesdens and Flamstead. Neither of these areas coincides with a distinct region of geology, relief, or soils. The eastern-most takes in areas with a range of clay, loam and chalk soils, while the western concentration consists mainly of loams on the dip-slope of the Chiltern scarp, but includes also some much chalkier areas in the very north-west. Clearly though, high valuation farms were very rare in the southern half of the county, even though large numbers of inventories survive for this area. A preliminary evaluation of this pattern then, would suggest that the increases in yields may have been concentrated in (although not necessarily confined to) particular areas within the county, mainly on lighter soils.

It would clearly be too simple to assume that higher yield areas in the second half of the century were the only locations of increased yields, or that the amount by which yields were higher than average on these farms represented the amount by which they had increased, since it is unlikely that yields had previously been approximately the same all over Hertfordshire. Even so, the emergence of much more distinct high valuation clusters suggests that there emerged distinct areas in

which either higher yields were achieved or that, for some reason, appraising conventions became regionally differentiated, with consistently higher valuations of growing crops produced in two areas through the use of new valuation procedures and conventions.

One way to investigate whether regions of higher valuations are an artifact produced by a change in conventions or their application is to apply a similar procedure to other farm items recorded in inventories, to see if similar regional patterns emerge. The most germane item is stored crops, since if different appraising conventions are being applied to growing crops, then we might expect them to be applied to grain once it had been harvested. However, no such regional pattern emerges from this procedure for wheat, barley, oats or pulses. In the circumstances, the possibility that the high valuation areas represent genuinely higher yields remains. While it cannot be shown that there were systematic variations in valuation procedures which can explain the pattern found, it would be unwise to ignore the tenuous assumptions involved in using per acre valuations as a surrogate for yields *at the level of the individual inventory*. We can be less confident of the geography of yields than about the aggregate trends discussed previously, but the pattern is not obviously an artifact.

Given the broad similarity in chronology between estimated yields and the increasing proportion of farmers whose inventories included valuations of ground prepared for crops, it is of considerable interest whether there are similar parallels between the geographical disposition of 'high yield' and 'ground preparing' farms. The increasing number of inventories which recorded ground preparation was indeed reflected in a wider geographical distribution, but this distribution was very uneven. It is striking that the densest occurrence of these entries lay in northern and

¹⁸ In Figure 3, 'high valuation farms' are drawn from the following years and decades: wheat 25 years (1660s 4 years, 1670s 5 years, 1680s 8 years, 1690s 8 years); barley 22 years (1660s 3 years, 1670s 4 years, 1680s 5 years, 1690s 10 years); oats 16 years (1660s 5 years, 1670s 3 years, 1680s 4 years, 1690s 4 years). These 63 valuations relate to 51 different farms since some farms had high valuations of more than one crop. Each of these farms is plotted only once in Figure 3.

central Hertfordshire, largely overlapping the major concentration of 'high valuation' farms (compare figures 3 and 4). Before 1649 there was a slight concentration of ground preparation in the second 'high valuation' area in the west of the county, but overall these entries appeared here only slightly more frequently than in southern Hertfordshire generally.

Since the pattern of soils at a local scale is highly complex, and the location of lands in an inventory cannot usually be resolved below the scale of the parish unit, relationships between ground preparation and the nature of the soil being prepared can only be explored in general terms. The practice was far more common on predominantly chalky and loamy soils than on the heavier clays and infertile gravels to the south. In a general sense, therefore, the new methods were mainly to be found on lighter soils, though not in all light soil areas. This is consistent with the expectations of what has been termed the 'John-Jones' model of early modern agricultural innovation, which emphasizes light soil mixed farming systems as the pre-eminent location of attempts to raise arable yields in response to depressed grain prices after c. 1650.¹⁹

The characteristics of farms on which ground preparation was being recorded in inventories can easily be compared with those of farms where ground preparation was not recorded. In the 1690s, there were thirty-three active farmers whose inventories mention ground preparation and ninety-six other active farmers. The composition of the farm wealth of the two groups is compared in Table 2. It is apparent that the innovating farmers were operating much larger farms than their non-innovating counterparts (the two groups

of inventories having a similar seasonality pattern), although the relative importance of crops, stock and equipment as components of total farm valuation was similar. As might be expected given the contrast in livestock valuations between the two groups, the 'ground preparers' owned a much greater variety of livestock, over 80 per cent of them owning some of each type tabulated. Also noteworthy is their greater adoption of clover and other new grasses. Nine of thirty-three 'ground preparers' had inventories including new grasses compared with only a handful of other farmers. Thus not only was ground preparation geographically concentrated, but it was mainly a feature of large farms, and farmers carrying out ground preparation were more likely to be growing 'new' fodder crops than their contemporaries (even though by the 1690s the distribution of 'fodder crop growers' showed no particular geographical concentration).

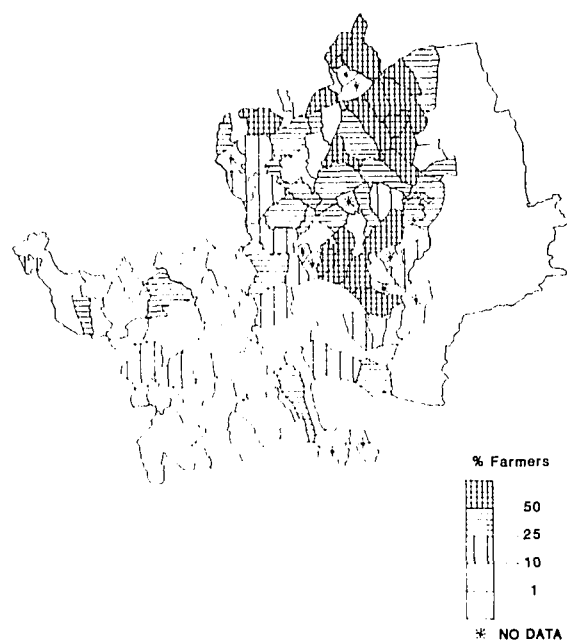


FIGURE 4
Percentage of farmers' inventories containing valuations of prepared ground, 1660-1699.

¹⁹ Although John and Jones were concerned mainly with innovations of fodder crops, rather than the techniques being considered here.

Similarly, where inventories were compiled during the summer months, and are sufficiently detailed, the types of farm on which ground preparation was most frequent can be identified. In the context of the pattern of production changes already discussed, and the wealth characteristics of different types of farms, it is no surprise to find that the various types of grain-oriented farm were the major setting for ground preparation, or that it was particularly associated with the large sheep-corn farms, whose growing numbers and size have already been highlighted in sections IV and V.²⁰

IV

This exploration of crop yields in Hertfordshire has suggested that significant improvements in output per acre had occurred by 1700. Improvements were concentrated in the later seventeenth century which, as earlier writers have noted, is slightly surprising given prevailing depressed prices for agricultural produce, especially grains. Despite generally stagnant or falling grain prices, and unfavourable price relatives between grain and livestock prices, arable output per farm increased sharply. There were three distinct components to this. First, average farm size was increasing, and the relative importance of crops and livestock did not change greatly. Secondly, average yields per acre for several crops were increasing. Thirdly, shifts in the relative importance of particular crops were away from lower yielding and lower quality crops (such as rye) and towards higher yielding grains (such as barley, of which both the yields and the cultivated area rose substantially). The timing of these increases in arable output raises a number of questions.

Neither the innovation of new fodder crops nor increased livestock numbers

seem able to account for the yield increases described. While both developments can be discerned, neither of them occurred on a sufficient scale to account for a widespread improvement in yields. Instead, higher yields may be due to the more careful and more systematic ground and seed-bed preparation prior to sowing, reflected in the increasingly frequent valuations of such work which appear in inventories. These activities both reduced the impact of some types of adverse weather (for example, the impact of long dry spells, where the moisture retaining capacities of light soils were enhanced) and allowed higher yields than hitherto to be achieved under average or better conditions (through the addition of various fertilizers).

Hertfordshire agriculture was characterized on the one hand by relatively high yields, and on the other by relatively low livestock densities, high levels of manuring, considerable ploughing and weeding of fallows, and the widespread cultivation of peas and other pulses. It is intriguing that this combination of features echoes that stressed by Campbell with regard to some distinctively high-output medieval estates in north-east Norfolk.²¹

Obviously the parallel between fourteenth-century East Anglia and seventeenth-century Hertfordshire should not be overdrawn. The social, organizational and institutional contexts of the two areas at these widely separated times were clearly very different. Nevertheless, in both cases, higher crop output per acre resulted from a similar pattern of intensification of certain inputs to arable systems. If greater attention to ground preparation underlay increased yields in seventeenth-century England, medieval and early modern yield increases had much in common. The higher crop yields of the later seventeenth century cannot be seen as indicating a

²⁰ *Ag Hist Rev*, 36, pp 68-72.

²¹ B M S Campbell, 'Agricultural progress in medieval England: some evidence from east Norfolk', *Econ Hist Rev* 2nd series XXXVI, 1983, pp 26-46.

decisive break between medieval and modern agriculture, but rather continuity in the techniques by which land productivity could be raised. A more important difference between the two periods lay in new configurations of social and institutional structures, such that more labour intensive techniques were not confined to a few particular geographical contexts, as they had been in the thirteenth and early fourteenth centuries.²² A decisive break between medieval and modern techniques *per se* awaited much later changes of mechanization and artificial fertilizers.

It is unhelpful to assume that early modern yield increases were attained in one uniform way, a view recently neatly summarized by O'Brien:

'At the core of a protracted process . . . [of agricultural change] . . . was a set of fodder crops which offered a solution to the age-old problem of how to raise the capacity of farmland to carry more animals. By the early nineteenth century (perhaps long before), a major distinction between England and large parts of continental Europe was the more animal intensive character of its agriculture'.²³

It would be foolish to deny that the introduction of crops such as clover and turnips was later of critical importance, but they were not *necessary* conditions for sustained improvements in crop yields.

The continued arable emphasis of Hertfordshire agriculture, and the chronology of increasing crop yields, fit fairly comfortably with E L Jones's notion that farmers committed to arable production might respond to falling prices by attempting to raise grain output and hence maintain farm revenue. However, the ways in which I have suggested grain output was increased differ from those envisaged by Jones in two ways. First, in emphasizing ground

preparation rather than new fodder crops backed up by higher livestock densities; and second, because Jones emphasized cost-cutting strategies for farmers, whereas the evidence presented here concerns the wider use of labour intensive techniques.

The latter feature raises the question of why labour-intensive innovations would have been introduced at a time when labour was becoming more expensive (insofar as agricultural wage rates were rising in real terms). But whether increased labour inputs actually raised farmers' costs depends on the form and organization of farm labour. If extra labour inputs were drawn from servants on annual contracts, then they would not in themselves have increased labour costs, unless more servants were hired. And this was a period in which the importance of farm servants increased at the expense of day labourers in regions of arable and mixed husbandry, as real daily wage rates increased after c. 1640.²⁴ Even if ground preparation was performed entirely by day labourers, quite minor changes in the *pace* of work could bring about significant changes in labour productivity. At all events, it is difficult to interpret ground preparation as anything other than deliberate modification of agricultural practice. We cannot argue that yields were raised 'inadvertently' by moves towards more pastoral types of agriculture.

The general thrust of this argument is consistent with Jones's suggestion that some farmers were attempting to invest their way out of falling incomes, even though this ensured in the medium term that grain prices would remain low. It is not easy to substantiate the suggestion that investment by farmers increased, since we cannot trace actual income, investment expenditure or consumption expenditure from inventories. The relation between these money flows and the capital stocks recorded in inventories is unlikely to be

²² In particular, the relationships among enclosure, market integration and ground preparation demand attention.

²³ P K O'Brien, 'Agriculture and the home market for English industry, 1660-1820', *Eng Hist Rev*, 100, 1985, pp 773-800, quote from p 779.

²⁴ Kussmaul *op cit*, pp 97-119.

straightforward, but we can make simple comparisons between the wealth represented by a farmer's farm equipment, and by his personal and household possessions.²⁵

Figure 5 shows the outcome of this comparison for all the farm inventories. The graph plots the importance of total valuations of farm equipment (gear, tools etc.) relative to the combined total valuations of farm equipment and household goods. This is clearly a very crude calculation, since changes in the value of farm equipment provide only a poor surrogate for investment, and changes in the valuation of household goods provide only a poor surrogate for consumption. Even so, the steady upward trend of farm equipment valuations relative to household goods valuations from the middle decades of the seventeenth century provides food for thought. The most obvious explanation of this trend is that patterns of spending changed. This in turn can most easily be explained by changes in attitudes towards investment. It is certainly not the product of a withdrawal from consumption, as is clear from detailed analysis of the volume and composition of farmers' inventoried household goods.²⁶

Thus far I have accepted the arguments of Jones and others that price relatives were moving away from the arable sector to favour the producers of livestock and livestock products, and that shifts in price relatives underlay some changes in agricultural specialization. This orthodoxy has

Farm equipment as % of
equipment and household goods

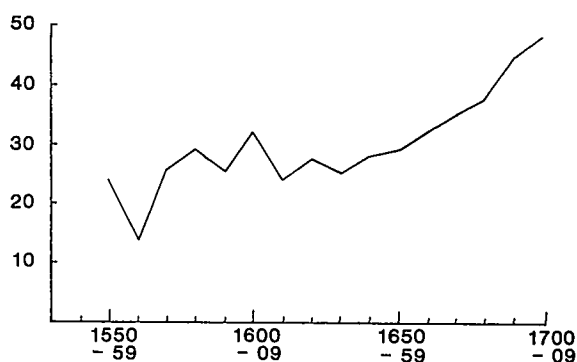


FIGURE 5

Trends in mean valuation of farm equipment relative to mean valuation of household goods.

recently been challenged by O'Brien.²⁷ O'Brien develops new price series for the period 1660-1815 covering grain prices, animal products, and a variety of industrial commodities. He argues that

'the new price indices suggest that the reallocation of resources from arable to pastoral husbandry had little to do with inducements offered by shifts in relative prices. Between 1660 and 1820 the movement in the relative prices of grains compared to animal produce is almost imperceptible. ... On balance, English farmers were not receiving the strong price signals (posited by several agrarian historians) to shift land and other resources from arable to pasture.'²⁸

Whilst the availability of high quality price series for many commodities is a major step forward, there are several respects in which O'Brien's series reveal much more about the situation of consumers than the situation of farmers. The most important is that he is concerned with prices per unit of sale (per bushel, per lb, per pint of milk, etc.), not with prices per unit of production (per acre of crops, per sheep, per cow). Prices per item of sale (at wholesale markets, moreover) are unlikely to have borne a constant relation

²⁵ 'Farm equipment' includes gear such as carts, ploughs, harrows, wheels, husbandry tools, measures, and dung and compost, together with some items involved in processing such as malt mills, malting equipment, and shears. 'Household possessions' include all furniture, ornaments, clothing, linens, brass, pewter, ironware, and luxuries such as gold, silver, plate, books and clocks. They do not include either cash in the deceased's purse or elsewhere in the house, and take no account of debts owed to or by the deceased.

²⁶ P. Glennie, 'The emergence of a consumer society in south-east England' (forthcoming).

²⁷ O'Brien, *op cit.*

²⁸ O'Brien, *op cit.*, pp 779.

to prices per unit of production over the limited period 1660-1700, let alone the period 1660-1820. For O'Brien's price series to be useful in summarizing the income situation facing farmers, two assumptions would have to hold. Both relate to stages intermediate between the farmer's decision to produce and the market.

The first assumption is that the relative importance of production and transport costs contained in wholesale prices was constant, or at least that it shifted at the same speed for different commodities. If grain, livestock or animal products could be got to market, or sold via middlemen outside open markets, more efficiently, then we would expect wholesale prices to move partly independently of farmers' profits. Chartres suggests that several important developments were underway in this period, and that they affected some sectors, and some regions, very much more than others.²⁹

The second assumption is that it is unnecessary to take account of productivity changes in agriculture, yet we can be sure that these will be highly disruptive to the relationship between market prices and farm profits. The interpretation of series of prices per unit of sale in terms of farmers' incomes is hazardous where, for example, the productivity of livestock or crop yields per acre are increasing. Yet in the case of grains, this is precisely what John and Jones suggest was crucial in shaping farmers' reactions! The yield increases discussed above have been inferred from the divergence of trends in valuations per bushel of stored grain (i.e. the price per unit of sale) and valuations per acre of growing grain (i.e. the price per unit of production). Similarly, if animals were getting larger, leaner, or higher-yielding of wool, milk and so on, then prices per unit of produce fail to provide an appropriate

measure of income potentially available to farmers from particular types of livestock husbandry. O'Brien's claim that farmers did not receive price-driven income signals reflects a method which brackets out the possibility of the very productivity shifts whose existence we want to investigate.

The O'Brien price series also raise the problem of the applicability of national or multi-regional price series in the explanation of regional or local level trends in farm income. On the one hand, there is little doubt but that inter-regional price differentials for most commodities diminished during this period, and that a more nationally integrated marketing system for agricultural commodities was reflected in a greater synchronism in price movements in different parts of the country. On the other hand, changes in crop yields and the quality and productivity of livestock are each likely to have been concentrated in particular areas. Consequently, the relationship between price per unit of sale and price per unit of production was probably at least as variable geographically as it was temporally. It would be most surprising if the precise patterns of geographical variation did not change substantially over time.

Overall, then, considerable caution is required in attempting to infer the consequences for farm income of farmers' land-use decisions from series of wholesale or retail prices. Moreover, the degree to which farmers were price-responsive appears to have changed during the seventeenth and eighteenth centuries, as landholding became more polarized and less subsistence-oriented, and as cultural changes prompted shifts in how both landlords and tenants regarded the purpose and aims of farming.³⁰

²⁹ J Chartres, 'The marketing of agricultural produce', *AHEW* V II, pp 406-502.

³⁰ J Thirsk, 'Agricultural policy: public debate and legislation' and 'Agricultural innovations and their diffusion' in Thirsk (ed), *AHEW* V II, pp 298-388 and 533-89, especially pp 546-59; K Tribe, *Land, Labour and Economic Discourse*, 1978, pp 53-79; K Wrightson, *English Society, 1560-1680*, 1982, pp 135-6.

V

This paper has dealt only with trends in crop productivity per acre. Labour productivity remains almost inaccessible. Neither do inventories offer much insight concerning trends in livestock productivity. Changes in the number of livestock per farm can easily be calculated, but the size of animals, the quality of their outputs, the combination of outputs they produced, and the throughput (or speed of turnover) of animals through the farm cannot be determined. All of these are ways in which livestock productivity could increase without involving larger herds or flocks. The way in which inventories were compiled, and the lack of contemporary understanding of breeds and genetics, means that improvements (or at least interest) in livestock quality can only occasionally be suspected, for example in unusually specific entries such as Henry Edlin's '6 milchbeasts or kine and 1 heireford calfe' worth £17 10s 0d at Watford in 1614.³¹ Even in entries like these, however, we cannot be sure exactly what his appraisers meant by 'heireford', and the chronology of general improvements in livestock husbandry is likely to remain obscure.³²

The foregoing discussion raises at least as many questions as it answers. In several sections, the inventory data have been pressed quite hard, and further quantitative analyses of data from probate inventories are needed before the methodological acceptability of particular measures of agricultural activity can be adequately evaluated. In particular, the attempt to use high per-acre valuations of growing crops to identify individual farms on which yields were high reveals some highly suggestive

regional patterns, but may go beyond the range of legitimate inference in ascribing these to genuine yield differences rather than other factors. To some extent it will be easier to judge the validity of this approach once further studies are available and the plausibility of the patterns which they produce. However it would probably be naïve to expect an unambiguous verdict.

If it were to be concluded that the exploration of 'yields' at the level of the individual farm is useful, then two particular investigations would be worthwhile. First, a more detailed comparison of 'yield' and innovations, whether ground preparation, new crops or others. Secondly, an investigation of the relationship, if any, between 'yield' and some measure of investment.

The answers to further questions (such as the relationship between enclosure and yields, how input changes were understood and communicated, the detail of relationships between local topography, crops and yields, and direct measures of labour productivity) clearly cannot be approached adequately using inventories alone.

These enquiries also require the integration of the present aggregate-level analysis with more detailed local studies: for example, the relationship between enclosure and ground preparation practices, or trends in the size of the agricultural labour force and the intensity of its work. Both the application of new analytical techniques, and the integration of research focusing at very different geographical scales, will be of central importance in answering the many questions directly raised, and indirectly stimulated, by the *Agrarian History* volume V, and by reviewers and commentators.

Appendix 1

Methods of yield estimation

Methods such as Overton's which estimate yield trends by comparing pre-harvest valuations of standing grain with post-harvest valuations of stored grain face

³¹ HCRO ASA 25/2360. This is the earliest such mention found. Examples are rare before the 1680s.

³² A very crude measure would be to divide the selling prices of particular types of livestock by the selling prices of particular animal products, but the multi-purpose role of most animals means that this is a much more dangerous procedure than the equivalent calculation for crops. For a recent overview of the field, see N Russell *Like engend'ring like: heredity and animal breeding in early modern England*, Cambridge, 1986.

problems because only a minority of inventories specify areas/volumes and prices for cereal crops individually.³³ Many inventories are excluded because they refer to the 'wrong' time of year, or because they value combinations of crops (e.g. '85 acres of wheat and barley' ... £100) or because they lump valuations (e.g. '17 acres of wheat and 12 acres of oats... £25') or because they omit quantity (e.g. 'the barley in the barn ... £25').

Hence it is almost unavoidable, unless inventories from a very large area are grouped together, that inventories from more than one year are grouped together for analysis. Where our main interest is in long-term trends in yields rather than short-term fluctuations some temporal lumping of inventories is appropriate in any case. However, there is more than one way in which temporal lumping can be incorporated into Overton's procedure.

Overton's preferred method is to reach an average 'yield' figure by dividing every per acre valuation from the same run of years. The resulting figures are then weighted according to the number of inventories available for each combination of years, and summed to produce an overall estimate for the period. The weight applied to a single calculation is given by

$$\frac{1}{(a \times b \times c)}$$

- where
- a = square of number of years in period
 - b = number of inventories with usable valuations per acre for a given cereal crop
 - c = number of inventories with usable valuations per bushel for a given grain.

³³ This is particularly true for grains other than the major cash crops of wheat and barley.

Thus if ten-year periods are used, in a year for which there are 12 usable valuations of growing wheat and 10 of stored wheat, each of the former divided by each of the latter contributes $1/(100 \times 12 \times 10)$ to the estimated average wheat 'yield' for that ten-year period.

As Overton recognizes, the utility of a measure produced by dividing the frequency distribution of valuations per acre by the frequency distribution of valuations per bushel depends on both distributions being approximately normal statistically. Unfortunately, the distribution of per acre valuations in the case of Hertfordshire is rather right-skewed in the earlier decades, especially for wheat, (i.e. there is a small number of valuations which are much larger than average and which exert a disproportionate upward influence on the final estimate).³⁴

It is more appropriate here to follow Allen's suggestion of calculating the mean figure for each year separately (by dividing each per-acre valuation by the average per-bushel valuation), and of averaging these annual averages to produce an estimated 'yield' for a longer time period.³⁵ It is this procedure which produced the estimates

³⁴ A right-skewed distribution has a particularly dramatic effect because grain valuations increase disproportionately in years of below average yield. A reduction in yield of say 20% below average produces a price increase of much greater than 20%. On the other hand, yields 20% above average produce a smaller decrease in price than the lower yield did an increase. This asymmetry means that a few high per-acre valuations as the numerator in a 'yield' calculation have a much greater effect than a few eccentrically high per-bushel valuations as the denominator. Thus overestimates of average yield will be produced by Overton's method when per-acre valuations are right-skewed. The whole issue of the relationship between gross yield, net yield, and price changes is discussed with great insight in E A Wrigley 'Some reflections on corn yields and prices in pre-industrial economies' in his *People, cities and wealth: the transformation of traditional society*, Oxford, 1987, pp 92-130.

³⁵ I have not followed another of Allen's suggestions, which is to use market prices of grain instead of the inventory valuations per bushel. The latter are lower than the former, presumably reflecting both the additional costs of transporting grain to market and the likelihood that not all grain valued in inventories would have been of marketable quality. Since this would certainly be true of standing grain valued in the fields, it seems appropriate to use inventory valuations of both pre- and post-harvest grain.

TABLE 3
Estimates of mean per-acre valuation in bushels

	<i>Modified method</i>		<i>Unmodified method</i>	
	<i>Wheat</i>	<i>Barley</i>	<i>Wheat</i>	<i>Barley</i>
1550-59	(8.2)	(10.5)	(9.0)	(11.8)
1560-69	8.4	12.2	9.2	13.1
1570-79	9.0	11.5	9.2	11.8
1580-89	9.7	10.9	10.2	11.0
1590-99	9.9	10.9	10.5	10.7
1600-09	9.7	14.1	10.9	12.8
1610-19	9.2	13.4	10.6	13.0
1620-29	8.6	11.0	9.8	11.8
1630-39	8.3	10.4	9.4	10.2
1640-49	10.3	11.5	9.8	10.2
1650-59	(12.7)	(13.3)	(10.8)	(11.8)
1660-69	15.1	13.5	11.1	13.7
1670-79	15.4	20.2	11.0	16.3
1680-89	14.6	22.4	11.0	17.1
1690-99	13.4	19.8	11.3	17.0

Note: Periods used are three-decade moving averages, centred on the decade shown. Figures in brackets are based on small numbers of inventories and include years from which no inventories survive (the early-1540s and mid-1650s).

plotted in Figure 1. A comparison with the results produced by the unmodified Overton method is given in Table 3.

The two methods produce differing estimates of 'yields' at a number of points but they are in broad agreement over the timing of trends. The skewed distribution of per-acre valuations in the early decades is reflected in the higher wheat 'yields' estimated using Overton's method. Towards the end of the seventeenth cen-

tury, when the distribution of per-acre valuations is less skewed, the 'yields' calculated by the unmodified method are below those obtained by the modified method, though above those of the decades around 1600. To reiterate: the Overton method under-estimates the increase in 'yields' because of the greater degree of right-skew in the frequency distributions of per-acre valuations in the first half of the study period.