Re-establishing the English Agricultural Revolution*

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Abstract
This paper makes a case for re-establishing the eighteenth and early nineteenth centuries as a crucial period of agricultural advance in England worthy of the description 'agricultural revolution'. It therefore counters the stream of claims made since the 1960s that developments in earlier centuries were of more significance. The two key indicators of progress are taken to be, first, an unprecedented increase in agricultural output brought about by an equally unprecedented increase in land productivity, and, second, an unprecedented increase in labour productivity which was a necessary corollary to industrialization. New evidence is presented to demonstrate that these changes were mainly a feature of the period from 1750, and, although the seventeenth century was not devoid of developments in agricultural technology, it was not until the late eighteenth and early nineteenth that these and other developments came to fruition in an 'agricultural revolution'.

For many years the fortunes of English agriculture from the early modern period onwards have been discussed in terms of the existence or otherwise of particular 'agricultural revolutions'. Periods of 'revolutionary' change have been identified for at least five periods between 1560 and 1880, and each has been characterized by a different combination of 'significant' agricultural developments. Debate about the character and chronology of these 'revolutions' has reached something of an impasse in recent years, partly because they have not been backed up by sufficient quantitative evidence, and partly because too little attention has been given to the criteria by which the 'significance' or otherwise of agricultural change should be judged. Yet the substantive issues with which the debate has been concerned remain of central importance to understanding the development of both English agriculture and the English economy.[1]

Of the various periods under consideration, it is remarkable that the least popular contender for the title of 'agricultural revolution' is the century after 1750. This period was identified by an early generation of agricultural historians as the period of the 'agricultural revolution', and subsequently by Chambers and Mingay in their influential textbook published in 1966.[2] However, most contributors to the debate have emphasized the significance of earlier periods. Kerridge considered that 'the agricultural revolution dominated the period between 1560 and 1767 and that all its main achievements fell before 1720, most of them before 1673, and many of them much earlier still'.[3] Writing in the 1960s Jones considered that from the mid-seventeenth century 'English agriculture underwent a transformation in its techniques out of all proportion to the rather

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[1] Recent reviews of the agricultural revolution include Mark Overton, 'Agricultural revolution? Development of the agrarian economy in early modern England', in A R H Baker and D Gregory, eds, *Explorations in Historical Geography: Interpretative Essays*, 1984, pp 118–39; *idem*, 'Agriculture', in John Langton and R J Morris, eds, *Atlas of Industrializing Britain 1780–1914*, 1986, pp 34–53; J V Beckett, *The Agricultural Revolution*, Oxford, 1990; Mark Overton, 'Agricultural revolution? England, 1540–1850', in A Digby and C H Feinstein, eds, *New Directions in Economic and Social History*, 1989, pp 9–21. Further development of some of the arguments in this paper will be found in Mark Overton, *Agricultural Revolution in England: The Transformation of the Agrarian Economy, 1500–1850*, 1996.

[2] R E Prothero, *English Farming Past and Present*, 1912; P Mantoux, *The Industrial Revolution in the Eighteenth Century*, 1928, pp 156–61; J D Chambers and G E Mingay, *The Agricultural Revolution, 1750–1880*, 1966.

[3] E Kerridge, *The Agricultural Revolution*, 1967, p 328.

limited widening of the market', and 'If there was a revolutionary phase it ... had come during the Commonwealth and Restoration periods', and his conclusions were reinforced by the work of John.[4] Thus Wallerstein, in his survey of the secondary literature published in 1980, found a 'widespread historiographic impression that England had an agricultural revolution *circa* 1650 to 1750'.[5] The verdicts on agrarian developments from the sixteenth century in the authoritative Cambridge *Agrarian Histories*, published during the 1980s, have done nothing to clarify matters. *Volume V* concludes that for the century after 1650 a depression in grain prices prompted innovation and enterprise, but the full harvest of this ingenuity in the form of an 'agricultural revolution' was not reaped until after 1750.[6] On the other hand, the succeeding *Volume VI*, dealing with the period 1750–1850, considers that although the agricultural changes in the century after 1750 were remarkable, 'It could hardly be said that they amounted to an agricultural revolution', since they were a limited preparation for the greater changes yet to come.[7]

In the 1990s, two important contributions have reinforced the view that the 'agricultural revolution' was a phenomenon of the period before 1750. Allen has argued that what he calls the yeoman's agricultural revolution occurred mainly in the seventeenth century: 'most of the productivity growth in early modern England was accomplished by small farmers in the open fields during the seventeenth century' and was marked by a 'doubling of corn yields', whereas the eighteenth century saw a landlord's revolution through enclosure which did not increase output but redistributed income from farmers and labourers to landlords.[8] Finally, Clark in a general discussion of the 'agricultural revolution' has concluded, 'There was no agricultural revolution between the early eighteenth and mid nineteenth centuries', and offers the extraordinary opinion that 'the finding of little productivity growth in agriculture from 1700 to 1850 is consistent with all of the reliable information we have for agriculture in this period'.[9]

There is some very recent evidence to suggest that the tide is starting to turn against this revisionism. In a recent paper on Norfolk it was argued that 'it is the period after 1740 that clearly emerges as having undergone the most rapid and profound transformation of technology and productivity',[10] and for the same county it has also been claimed that for the thirty years after 1790 'an almost complete break with the past was made over the working lives of one generation of farmers'.[11] More importantly, perhaps, Devine has recently argued that 'there was a radical departure from the pattern of the past in the last quarter of the eighteenth century' in the agriculture of lowland Scotland.[12] Scotland is not England, but agricultural practice in the lowlands was not unrelated to that in parts of England. In this paper I shall argue

[4] E L Jones, 'Agriculture and economic growth in England, 1660–1750: agricultural change', *Jnl Econ Hist*, XXV, 1965, p 1; *idem*, 'Agriculture, 1700–80', in R Floud and D McCloskey, eds, *The Economic History of Britain since 1700*, 1981, p 85. John's contributions include, A H John, 'The course of agricultural change, 1660–1760', in L S Pressnell, ed, *Studies in the Industrial Revolution*, 1960, pp 125–55; *idem*, 'Agricultural productivity and economic growth in England, 1700–1760', *Jnl Econ Hist*, XXV, 1965, pp 19–34; *idem*, 'Aspects of economic growth in the first half of the eighteenth century', *Economica*, new ser, 28, 1961, pp 176–90.

[5] I Wallerstein, *The Modern World-System II*, 1980, p 263.

[6] J Thirsk, ed, *The Agrarian History of England and Wales, V, 1640–1750: Part II, Agrarian Change*, 1985, pp xxx-xxxi.

[7] G E Mingay, ed, *The Agrarian History of England and Wales, VI, 1750–1850*, 1989, pp 953, 971.

[8] R C Allen, 'The two English agricultural revolutions, 1450–1850', in Bruce M S Campbell and Mark Overton, eds, *Land, Labour and Livestock: Historical Studies in European Agricultural Productivity*, Manchester, 1991, p 236; *idem*, *Enclosure and the Yeoman. The Agricultural Development of the South Midlands 1450–1850*, 1992, p 21.

[9] G Clark, 'Agriculture and the industrial revolution, 1700–1850', in J Mokyr, ed, *The British Industrial Revolution: An Economic Perspective*, 1993, pp 246, 249.

[10] Bruce M S Campbell and Mark Overton, 'A new perspective on medieval and early modern agriculture: six centuries of Norfolk farming, *c.*1250–c.1850', *Past and Present*, no 141, 1993, p 105.

[11] Susanna Wade Martins, 'From black-face to white-face – an aspect of the agricultural revolution in Norfolk', *Ag Hist Rev*, 41, 1993, p 30.

[12] T M Devine, *Transformation of Rural Scotland: Social Change and the Agrarian Economy, 1660–1815*, Edinburgh, 1994, p 165.

the case that the years from *c* 1750 to *c* 1850 witnessed unprecedented changes in output and productivity in English agriculture, which warrant appellation of the term 'revolution'.

In attempting to re-establish the case for an agricultural revolution during this period, I shall first examine the evidence of changes in output and of the productivity of land from the sixteenth century onwards; second, discuss the evidence of husbandry developments which may have contributed to these changes; third, provide some evidence of changes in labour productivity; fourth, briefly review the hypotheses that might account for changes in labour productivity; and finally, in the light of this evidence, offer some criticisms of recent revisionist interpretations of the 'agricultural revolution'.

I

Resolution of the question as to whether or not an 'agricultural revolution' took place during a particular period is both a conceptual and an empirical issue. Whether or not agricultural developments in particular periods are interpreted as revolutionary depends on how the concept of an 'agricultural revolution' is defined. Three sets of criteria can be identified in the literature as implicitly or explicitly constituting the grounds for claiming an 'agricultural revolution'. The first of these embraces a wide variety of changes in farming techniques. These range from the introduction of new fodder crops and new crop rotations, the watering of meadows, the improvement of livestock breeds, and the introduction of machinery.[13] The second is the fact that English agriculture was successful in responding to the challenge of feeding a growing population, an argument that has been employed for the sixteenth and early seventeenth centuries, and for the century after 1750.[14] The third is the view that an 'agricultural revolution' is best characterized as an increase in output brought about by improvements in productivity, where productivity is defined as output per unit of input. Indices of productivity vary depending on the combinations of inputs and outputs employed. The two most important agricultural inputs, and therefore the two most important productivities, are land and labour.[15] Grigg first stressed the importance of productivity change as an indicator of an 'agricultural revolution', and it has been accepted by most recent writers, including both Allen and Clark.[16] Earlier writers, however, have been rather reluctant to engage with concepts of productivity *explicitly*; their 'agricultural revolutions' are *implicitly* based on productivity change, although their concepts of agricultural productivity are woolly and ill-defined: for example, the productivity of land is often misleadingly equated with grain yields per acre (often for wheat alone) while discussions of the productivity of labour have been subsumed in the issue of the 'release' of labour from the agricultural to the industrial sector of the economy during the industrial revolution.[17]

It could be argued that these three conceptions of an 'agricultural revolution' are

[13] These are reviewed in Overton, 'Agricultural revolution? Development of the agrarian economy', pp 119–23.

[14] Chambers and Mingay, *Agricultural Revolution*, pp 3–4; Kerridge, *Agricultural Revolution*, p 332; G E Mingay, 'Dr. Kerridge's "Agricultural Revolution": a comment', *Ag Hist*, 43, 1969, p 497; R B Outhwaite, 'Rural England, 1500–1750', *Histoire Sociale – Social History*, 2, 1968, pp 85–97.

[15] Agricultural productivity is discussed in Mark Overton and Bruce M S Campbell, 'Productivity change in European agricultural development', in Campbell and Overton, *Land, Labour and Livestock*, pp 1–50. Eric Partridge, *Usage and Abusage: A Guide to Good English*, Harmondsworth, 1969, p 247 writes, '**productivity** is a horrible word; use output'. The first part of the statement may be correct but the second is not: productivity and output are not equivalent.

[16] D B Grigg, *The Agricultural Revolution in South Lincolnshire*, 1966, pp 190–1; Allen, *Enclosure and the Yeoman*, p 1; Clark, 'Agriculture and the industrial revolution', p 229; Overton, 'Agricultural revolution? England, 1540–1850', pp 18–19.

[17] For a discussion of confused conceptions of labour productivity see N F R Crafts, 'Income elasticities of demand and the release of labour by agriculture during the British industrial revolution', *Jnl European Econ Hist*, 9, 1980, pp 167–8.

rather narrow: they are concerned primarily with changes in the methods and techniques for producing food, with what Marx called the 'forces of production'. A wider conception of an 'agricultural revolution' would link these to changes in what he called the 'relations of production', which other writers sometimes refer to as institutional change. These issues are concerned with the establishment of private property rights to land, the replacement of feudal tenures and estates with leaseholds for a period of years, changes in the size of farms, and changes in the ways in which people were employed by others on the land. Yet a further way of looking at the issue would be in terms of the role of agriculture in the world-economy: when, in the nineteenth century, the English food supply network became global. However, in one sense at least this paper follows a conventional path since it is concerned with production and not primarily with distribution, institutional change, or the world-economy.[18]

In terms of the argument presented here, the twin achievements of the agricultural sector before 1850 of most significance are, first, the increase in output which was sufficient to break the 'Malthusian trap' and allow population to expand beyond the pre-industrial ceiling, and second, the increase in the productivity of labour in agriculture which was a necessary precondition for industrialization. If we take a very long term perspective – from the advent of sedentary agriculture in the neolithic period until well into the seventeenth century – output per unit of both land and labour was generally low and always prone to decline. In the absence of technological progress, agricultural output could only be raised by increasing inputs of land or labour or both. If new land was brought into cultivation thus raising output, it tended to be of lower quality than that already being farmed; therefore output per acre of the new land would be lower, which would bring down the average output per acre of all land being farmed. Similarly, output could rise if more labour was expended in growing crops, particularly for tasks like weeding. Although output might rise, output per worker would probably fall since the extra output secured by the additional labour would be less than the average output produced by each existing worker.[19]

From 1250 to about 1700 the population of England was unable to exceed a maximum of about 5.5 million. Whenever population grew – in the late thirteenth century or in the late sixteenth and early seventeenth centuries – it was unable to break through this ceiling. Although grain yields rose under pressure of this population growth, they too were unable to break through a ceiling of about 18 bushels per acre for wheat. Malthus' argument was broadly correct: the supply of agricultural products was limited by the area cultivated. Once all available land is cultivated then an output ceiling is set which limits the size of the population. This was Gregory King's assumption in the final decade of the seventeenth century when he made a forecast of English population growth. He was roughly correct in estimating English population at 5.50 million in the 1690s (in fact it was probably nearer 5.06 million), but thereafter his forecasts were increasingly wide of the mark: he forecast 6.42 million for 1800 (it was in fact 8.66 million) and 7.35 million for 1900 (in fact 30.51 million).[20]

King's forecasts were wrong because he failed to predict the agricultural revolution.

[18] Overton, 'Agricultural revolution? England, 1540–1850', p 19, discusses some institutional changes.

[19] Overton and Campbell, 'Productivity change in European agricultural development', pp 17–28.

[20] King's figures are reported in C Whitworth, ed, *The Political and Commercial Works of Charles d'Avenant*, 5 vols, 1771, vol 2, p 177. The relationship between the rate of growth of population and the rate of growth in food prices suggests that the 25-year period after 1786 marks a crucial turning point for agricultural production: see E A Wrigley and R S Schofield, *The Population History of England 1541–1871: A Reconstruction*, 1981, pp 402–12.

Technological change in agriculture enabled both output and land productivity to make a fundamental break with the past: population rose above 5.5 million in the late 1730s and continued to rise, and average English wheat yields rose above 18 bushels per acre by 1800 and continued to rise towards 30 bushels per acre by the mid-nineteenth century. At the same time, this increasing output was achieved by a declining *proportion* of the work-force; in other words the productivity of labour was rising as well, which is, of course, the necessary corollary of an industrial revolution defined as an increase in the proportion of the work-force in industry.[21] By 1800 England was unique in the world in having only about 30–35 per cent of its work-force engaged in agriculture.[22] The point is not about whether agricultural employment grew or declined in absolute terms, or whether there was a movement of people from the countryside to the towns, but whether more food was produced by each person working in agriculture.

II

Defining the changes in the agricultural sector of the economy which are held to be significant in this way sets the empirical agenda: the measurement of output and productivity. The absence of national statistics for either before 1850 obviously calls for some ingenuity in undertaking this task: three strategies are adopted in Table 1. The first method (referred to as 'population' in the table) takes the size of the population as an indicator of agricultural output, assuming constant consumption per head, but making allowance for exports and imports. This modification of population numbers with assumptions about exports and imports is essentially the procedure adopted by Deane and Cole in their estimates of agricultural output, although their population estimates have been superseded and their import figures refined.[23] The second method ('volume') employs direct estimates of the volume of output using a wide range of sources and is based mostly on the work of Chartres and Holderness in the Cambridge *Agrarian Histories*.[24] These estimates are based on information recorded by contemporaries, assumptions about the per capita consumption of various products, and scattered information from farm-based evidence. In some cases contemporary estimates have been revised and informed guesses have been used to interpolate the gaps. The revisions are often based on the evidence of population growth, assumptions about per capita consumption, and the progress of agricultural technology, which introduces a degree of circularity into their construction. Thus these volume output figures must be subject to quite a wide margin of error and are not independent of output estimates based on population growth. In addition, the interpolation of gaps in the time series may have the effect of smoothing over fluctuations. The third method ('demand equation') is that used by Crafts who points

[21] The productivity of labour is defined here as the output of agricultural products divided by the proportion of the work-force engaged in agriculture.

[22] G Grantham, 'The growth of labour productivity in the production of wheat in the *Cinq Grosses Fermes* of France, 1750–1929', in Campbell and Overton, *Land, Labour and Livestock*, p 341; Clark, 'Agriculture and the industrial revolution', p 228.

[23] P Deane and W A Cole, *British Economic Growth, 1688–1959*, 2nd edn, 1967, pp 64–75. For further details on these estimates see M Overton, 'Land and labour productivity in English agriculture, 1650–1850', forthcoming in Peter Mathias and John A Davis, eds, *The Nature of Industrialization, V, Agriculture and Industrialization*, 1994. Population figures are from Wrigley and Schofield, *Population History*; import and export estimates are from a variety of sources and are very rough; they make an allowance for imports from Scotland, Wales and Ireland.

[24] The combined value of the output of wheat, rye, barley, oats, potatoes, mutton, beef, pork, milk, butter, cheese, wool, tallow, and hides based on the estimates in J C Chartres, 'The marketing of agricultural produce', in Thirsk, *Agrarian History of England and Wales, V, Part II*, pp 406–502; Gregory King's estimates in J Thirsk and J P Cooper, eds, *Seventeenth Century Economic Documents*, 1972, pp 782–3; and B A Holderness, 'Prices, productivity and output', in Mingay, *Agrarian History of England and Wales, VI*, pp 84–189. Prices are from G Clark, 'Labour productivity in English agriculture, 1300–1860', in Campbell and Overton, *Land, Labour, and Livestock*, pp 215–6 and A H John, 'Statistical appendix', in Mingay, *Agrarian History of England and Wales, VI*, pp 974–1009.

TABLE 1
English agricultural output and productivity

	1300	*1600*	*1700*	*1750*	*1800*	*1850*
A) Output						
Output (population method)		80	100	121	159	272
Output (volume method)			100	127	191	285
Output (demand equation method)			100	143	172	244[a]
B) Area						
Arable area			100		128	170
Sown arable area			100		135	199
Meadow and pasture			100		147	103
Total area			100		138	132
C) Land Productivity						
Land productivity (population)			100		115	207
Land productivity (volume)			100		138	216
Crop productivity[b]	3.05					6.73
Livestock productivity[b]	1.04					6.56
Wheat yields[c]	79	72	100	123	136	180
Cereal yields[d]	115	92	100	135	158	250
D) Labour Productivity						
Labour productivity (population)		77	100	126	141	197
Labour productivity (volume)			100	134	170	206

[a] 1831; [b] Clark's estimates in wheat bushel equivalents; [c] Hampshire, Hertfordshire, Lincolnshire, Norfolk, Suffolk. The 1300 average is for Norfolk and Hampshire only; [d] Norfolk and Suffolk.
Sources: see text.

out that output trends based on population are inconsistent with the behaviour of agricultural prices. When agricultural prices are falling it is likely that per capita consumption of food will increase, and conversely when prices are rising per capita consumption should decrease. He therefore estimates agricultural output by taking prices and wages into account together with assumptions about the income and price elasticities of demand.[25]

Given the diversity in their methods of estimation it is comforting that all three estimates of output are in broad agreement: English agricultural output rose by between 2.5 and 3 times from 1700 to 1850 and more than doubled in the century after 1750. The principal difference between the estimates lies in the timing of growth in the eighteenth century, since Crafts' figures suggest a faster rate of growth in the first half of the century (when food prices were relatively low and per capita consumption may have increased) compared with the second half (when food prices were rising and per capita consumption may have decreased). Of the three estimates only the one based on population may be taken back before 1700, and from this perspective the turning point of the agricultural revolution mirrors the turning point in population growth: it is a phenomenon of the period after 1740. However, it is also the case that the rate of growth of agricultural output was more rapid than the rate of growth of population in the first half of the eighteenth century than it was over the succeeding 100 years from 1750 to 1850, when population growth was outstripping the growth in agricultural output. Population grew at an average of 0.26 per cent per annum from 1700–1750 whereas all the agricultural output indices grew more rapidly (ranging from 0.38 to 0.60 per cent per annum): from 1750–1850

[25] N F R Crafts, 'British economic growth 1700–1831: a review of the evidence', *Econ Hist Rev*, 2nd ser, XXXVI, 1983, pp 177–99; R V Jackson, 'Growth and deceleration in English agriculture 1660–1790', *Econ Hist Rev*, 2nd ser, XXXVIII, 1985, pp 333–51.

population grew at an average of 1.07 per cent per annum and the estimates of agricultural output ranged from 0.77 to 0.82 per cent per annum.

III

To measure land productivity we need to relate these estimates of output to estimates of land area (the input) in agricultural production. For 1700 we have to rely on the guesses of Gregory King, but by 1800 there are several independent estimates, and by mid-century some fairly reliable statistics.[26] While output went up by about 2.75 times between 1700 and 1850, the farmed area rose by 1.3 times. As Table 1 shows, the arable area increased by a greater amount, and the sown arable area nearly doubled, reflecting a decline in the area of fallow and an increase in the area of rotational grassland. Dividing output estimates by estimates of total area gives estimates of land productivity. These doubled between 1700 and 1850, suggesting that increases in productivity were more important than the growth in the land area, a development argued earlier to be of revolutionary significance.

These measures of land productivity are the preferred ones because they relate the total output of food to the total agricultural area. They can be compared with the popular but misleading indicator, wheat yields per acre. Cereal yields per sown acre can be a misleading guide to land productivity because they relate cereal output to the area sown with cereals and not to the entire arable area. For example, cereal yields per sown acre could be rising at the same time as cereal yields per arable acre were falling if land was being cropped at low intensity with long fallows. Thus, for example, a rotation in which wheat was followed by several years fallow might have high yields per *sown* acre of wheat, but a relatively low yield in terms of wheat output per *arable* acre which includes the fallow. Obviously wheat yields take no account of the yields of barley and oats (whose acreage exceeded that for wheat in England from 1300 to 1850), or of the productivity of livestock. However, using crop yields per acre it is possible to get information covering a much longer time span. Wheat yields per sown acre for five eastern counties show relatively little change from *c* 1300 to 1550; a growth rate of 0.46 per cent per annum from 1550 to 1650, 0.30 per cent from 1650 to 1750, and 0.35 per cent from 1750 to 1850. For the one county for which they are available, Norfolk, a weighted index of wheat, barley and oat yields (Tables 1 and 4) shows almost no change from 1300 to 1700, but a two-and-a-half-fold increase by 1850, reflecting proportionately greater yield increases for barley and oats than for wheat.[27]

For livestock we have less information. Clark has calculated land productivity for livestock products and for cereals at two benchmark dates, 1850 and *c* 1300, using fairly reliable contemporary estimates for southern England.[28] As the figures in Table 1 show, crop output per acre roughly doubles, but livestock productivity rises six fold. Unfortunately he is unable to calculate intervening estimates of livestock productivity.

Taking all these figures together suggests that for the country as a whole, land productivity may have risen threefold from 1300 to 1850, with a 50 per cent increase from 1300 to 1700 and a doubling, a 100 per increase, from 1700–1850. On the evidence of one county, almost all the increase in crop output per sown acre came

[26] H C Prince, 'The changing rural landscape, 1750–1850', in Mingay, *Agrarian History of England and Wales, VI*, p 30; see also D B Grigg, *The Dynamics of Agricultural Change*, 1982, p 185.

[27] Mark Overton, 'The determinants of land productivity in early modern England', in Campbell and Overton, *Land, Labour and Livestock*, p 306 gives the figures for both Norfolk and Suffolk from 1580. Table 1 is an abbreviation of tables in Overton, *Agricultural Revolution in England: The Transformation of the Agrarian Economy*.

[28] Clark, 'Labour productivity in English agriculture', pp 215–6.

after 1700, although for wheat (in five counties) the rise started earlier, around the middle of the sixteenth century. Nevertheless, it was not until the early to mid-eighteenth century that wheat yields were breaking through the medieval ceiling of around 18–20 bushels per acre. Although it seems that the magnitude of the rise in livestock productivity is much greater than that for crops, its chronology is unknown.

IV

This evidence points overwhelmingly to the eighteenth century as the period when changes in output and land productivity began to accelerate rapidly and reached unprecedented levels. In so far as it can be extended backwards there is little to suggest comparable increases in earlier periods. Further light can be shed on output and productivity change by looking at evidence of changes in agricultural technique, although the trap must be avoided of assuming that certain husbandry changes are necessarily indicative of productivity change, or that certain productivity changes imply certain husbandry changes. The presence of turnips and clover, for example, does not mean that cereal yields were necessarily rising, nor does evidence of yield increases imply the cultivation of turnips and clover.[29] But, if evidence of major changes in husbandry methods is coincident with a rise in land productivity then it adds weight to arguments about the chronology of productivity change based on the estimates shown in Table 1.

It is common to divide changes in output into those brought about by extensions to the cultivated area, and those brought about by changes in output per acre. The latter are held to be more important since they hold the promise of greater increases in output than do the former. Relatively little new land was available in the sixteenth century, when at least three-quarters of the land farmed today was being cultivated, yet between *c* 1500 and the present day average wheat yields have risen over twelve-fold.[30] In practice the distinction between extending the cultivated area and improving yields through technological change breaks down, for extensions to the cultivated area really involve an intensification of agricultural output, since virtually no land produced nothing. Thus the reclamation of fen, marsh, heath, moor, and woodland for arable farming merely involved replacing a low intensity agricultural system with one of higher intensity. Moreover, in some cases such reclamation would have been impossible without technological change of some kind: the best example perhaps is the conversion of heaths and downland to high intensity arable farming which was only possible with the use of grass substitutes like clover, and root crops like turnips.[31]

There is abundant evidence of land reclamation in England from the sixteenth century onwards but quantitative estimates are lacking until the eighteenth century. It is possible though that fen draining in the seventeenth century increased the arable area of England and Wales by up to 10 per cent. Over the course of the eighteenth century the estimates in Table 1 show that the area of arable, meadow and pasture grew by 38 per cent. But there was still much ground to conquer: Williams estimates that about 20 per cent of England

[29] P Glennie, 'Measuring crop yields in early modern England', in Campbell and Overton, *Land, Labour and Livestock*, p 255; *idem*, 'Continuity and change in Hertfordshire agriculture, 1550–1700: II – trends in crop yields and their determinants', *Ag Hist Rev*, 36, 1988, p 156; Mark Overton, 'The diffusion of agricultural innovations in early modern England: turnips and clover in Norfolk and Suffolk 1580–1740', *Trans Inst Brit Geogrs*, new ser, 10, 1985, pp 205–21.

[30] The figure of the area cultivated is a guess derived by working backwards from nineteenth-century estimates; the increase in wheat yields is assumed to be from an average of 10 bushels (roughly 0.25 tonnes) to 3 tonnes per acre.

[31] Overton, 'The diffusion of agricultural innovations'; *idem*, 'Determinants of land productivity', pp 319–20; Anon, 'Management of three farms in the county of Norfolk', *Gentleman's Magazine*, XXII, 1752, p 502.

and Wales was wasteland in 1800, but that this figure fell to 6–7 per cent by 1873.[32]

Agricultural production also intensified by increasing the area actually sown with arable crops through the reduction of land under fallow. Table 1 shows that the sown arable area almost doubled between 1700 and 1850 as the proportion of fallow fell. The first truly reliable estimates of the fallow acreage are not available until the 1830s (in the tithe files) when some 12 per cent of the arable area was still under fallow (Table 2), which fell to 4 per cent by 1871.[33] The 1700 estimate from King puts fallow at 20 per cent of the arable. This reduction in fallow was made possible by the introduction of root crops. Clear evidence for this is provided by the information in the tithe files. For England as a whole using county-based data, the correlation between the proportion of land under fallow and under turnips is a remarkable −0.84: in three counties using data for individual tithe districts the coefficient reaches −0.90.[34] Turnips first appear in England in the sixteenth century, and in certain parts of the country became common in the late seventeenth and early eighteenth centuries. Indeed, they were being grown by over half the farmers in Norfolk by 1720. Yet, as Table 3 shows, on average these farmers had only 7 per cent of their cropped acreage under turnips during 1660–1739, compared with 24 per cent in the 1830s, and the crops do not seem to have been cultivated particularly well. Thus even in the most famous and progressive agricultural county the major impact of turnips was after 1750, facilitating a reduction in bare fallows, assisting in the

TABLE 2
Crop proportions in England, 1801–71 (percentages)

A) Comparisons of single crops across time

	1801	*c 1836*	*1871*
Wheat	33	37	36
Barley	17	17	19
Oats	30	23	19
Peas & beans	10	8	10
Turnips	9	15	16
Potatoes	2	–	5
Clover/seeds	–	23	20
Fallow	–	12	4

Wheat, barley, oats, peas, beans, and turnips: percentage of wheat, barley, oats, peas, beans, and turnips.
Potatoes: percentage of wheat, barley, oats, rye, potatoes, peas, beans, and turnips.
Fallow and clover/seeds: percentage of wheat, barley, oats, peas, beans, turnips, clover, and fallow.

B) Comparisons within single periods

	1801	*c 1836*	*1871*
Wheat	32	23	25
Barley	19	13	14
Oats	26	12	12
Peas & beans	11	5	7
Turnips	8	11	12
Potatoes	2	–	3
Clover/seeds	–	22	22
Fallow	–	12	4

1801 counties: Bedford, Buckingham, Cambridge, Cheshire, Cornwall, Cumberland, Derby, Durham, Essex, Gloucester, Hampshire, Hereford, Kent, Lancashire, Leicester, Lincoln, Middlesex, Monmouth, Northampton, Northumberland, Rutland, Shropshire, Somerset, Stafford, Surrey, Sussex, Warwick, Wiltshire, Worcester, East Yorkshire, North Yorkshire, and West Yorkshire.
c 1836 counties: Bedford, Berkshire, Buckingham, Cambridge, Cheshire, Derby, Durham, Essex, Hampshire, Hertford, Huntingdon, Kent, Lincoln, Norfolk, Northumberland, Oxford, Rutland, Shropshire, Stafford, Suffolk, Surrey, Sussex, Warwick, East Yorkshire, North Yorkshire, and West Yorkshire.
1871: all English counties.
All available counties used in part (B); only those with extant information for all three periods used for part (A).
Sources: see footnotes 33 and 36.

[32] M Williams, 'The enclosure and reclamation of waste land in England and Wales in the eighteenth and nineteenth centuries', *Trans Inst Brit Geogrs*, no 51, 1970, pp 58–69.

[33] Many parishes enclosed by act of parliament would have had their tithes commuted at the time of enclosure. Thus the data in the tithe files may be biased towards open-field farming. Comparisons of farming in enclosed parishes with open parishes suggest the latter would have lower proportions of fodder crops like turnips and clover, slightly lower wheat yields, and significantly lower yields of barley and oats: Allen, *Enclosure and the Yeoman*; M E Turner, 'Agricultural productivity in England in the eighteenth century: evidence from crop yields', *Econ Hist Rev*, 2nd ser, XXXV, 1982, pp 489–510; *idem*, 'English open fields and enclosures: retardation or productivity improvements?', *Jnl Econ Hist*, XLVI, 1986, pp 669–92. The tithe file data are from R J P Kain, *An Atlas and Index of the Tithe Files of Mid-Nineteenth-Century England and Wales*, 1986, p 460; the 1871 data are from BPP, 1871, LXIX, *Agricultural Returns for Great Britain for 1871*.

[34] Pearson product moment coefficient. The county-based data are reproduced in R J P Kain and H C Prince, *The Tithe Surveys of England and Wales*, 1985, pp 226–8. Tithe district data are available from the ESRC Data Archive at the University of Essex.

TABLE 3
Norfolk: trends in agricultural production, 1250–1854

	1250–1349	*1350–1449*	*1584–1640*	*1660–1739*	*1836*	*1854*
Percentage Grain[a]						
Wheat	19	18	29	20	48	49
Percentage Sown Area[b]						
Grain	87	87	87	84	49	52
Legumes	14	13	9	14	27	24
Clover	0	0	0	2	25	21
Turnips	0	0	0	7	24	22
Livestock ratio[c]	32	36	51	70		61
Draught beasts[d]	8	6	14	11		11
Grain Yields[e]						
Wheat	15	12	15	15	23	30
WACY[f]	11	9	9	10	21	26

[a] Percentage of wheat, rye, maslin, barley, and oats; [b] Area sown with arable crops excluding fallow; [c] Livestock units per 100 cereal acres; [d] Oxen and horses per 100 sown acres; [e] Bushels per acre; [f] Weighted Aggregate Cereal Yield: see note 47.
Source: see footnote 10.

reclamation of light land, and providing more fodder for sheep and cattle.[35]

The introduction of turnips is one of the most dramatic and visible signs of changes in cropping, but there were others. The first cropping statistics providing anything approaching a national coverage come from the 1801 crop return, and these can be compared with evidence from the tithe files and the fourth of June returns already mentioned.[36] However, different crops were recorded for each of these three surveys, so Table 2 is divided into two parts: the first enabling comparisons to be made between time periods, and the second within time periods. Table 2A shows that there was little change in the proportions of wheat and barley over the first seventy years of the century, but a reduction in the proportion of land sown with oats. The other development was the increased cultivation of potatoes, albeit on a small scale nationally; locally however, the proportion of arable land under potatoes could be much higher than the national average and was over 25 per cent in Lancashire by 1871 for example.

[35] Overton, 'Determinants of land productivity', pp 306, 313.

[36] The 1801 data are discussed and presented in M E Turner, 'Arable in England and Wales: estimates from the 1801 crop return', *Jnl Hist Geog*, 7, 1981, pp 291–302.

Published information on crop proportions from the sixteenth century to the eighteenth century derived from probate inventories is available for at least nine counties. However, there are no changes in cropping which compare in speed or magnitude with the spread of turnips and clover in the eighteenth and nineteenth centuries shown in Table 2A. The only change of note is the decline of rye. Rye had never been common in some counties (such as Cornwall and Kent) but in others, especially Hertfordshire, Norfolk, Suffolk, and east Worcestershire the proportion of the sown acreage under rye declines from over 15 per cent in the sixteenth century to under 5 per cent by the eighteenth.[37]

The other trend evident from inven-

[37] The information in this paragraph is based on the quantitative evidence of crop proportions in J Whetter, *Cornwall in the Seventeenth Century*, Padstow, 1974, pp 46–7; P Glennie, 'Continuity and change in Hertfordshire agriculture: I – patterns of agricultural production', *Ag Hist Rev*, 36, 1988, p 61; C W Chalklin, *Seventeenth-Century Kent*, 1965, p 78; J Thirsk, *English Peasant Farming: The Agrarian History of Lincolnshire from Tudor to Recent Times*, 1957, pp 39, 78, 89, 102, 136, 157, 173, 188, 224–5, 246, 280–1, 302–3; Overton, 'The determinants of crop yields', p 306; W G Hoskins, 'The Leicestershire farmer in the sixteenth century', in *idem*, ed, *Essays in Leicestershire History*, Liverpool, 1950, pp 123–83; *idem*, 'The Leicestershire farmer in the seventeenth century', in *idem*, ed, *Provincial England*, 1963, pp 149–169; M A Havinden, 'Agricultural progress in open field Oxfordshire', *Ag Hist Rev*, IX, 1961, p 81; J A Yelling, 'Changes in crop production in east Worcestershire 1540–1867', *Ag Hist Rev*, 21, 1973, pp 18–34.

tories is the growth in the regional specialization of production from the second half of the seventeenth century onwards. In eastern Norfolk, for example, an intensive mixed husbandry developed centred on the production of wheat and the stall feeding of bullocks with barley. East Worcestershire also saw a swing to wheat, but within a less intensive husbandry system which saw a reduction in livestock densities. The rise of a specialist dairying industry has been charted in Shropshire and Hertfordshire; in the Midlands there appears to have been a swing to permanent pasture for the fattening of cattle.[38] These trends are reinforced by the indirect evidence from marriage seasonality which suggests increasing regional specialization from the 1660s.[39] Despite these changes prior to the mid-eighteenth century for Norfolk at least, 'the magnitude of the changes that occurred during the hundred years after 1740 were out of all proportion to those which had occurred during the preceding five hundred years', and changes of similar magnitude were happening elsewhere.[40]

This evidence of land reclamation and changes in crop proportions reinforces the view that increases in both output and land productivity were likely to have been more rapid from the eighteenth century onwards than before, and that these increases were accompanied by unprecedented changes in the crop mix and by the introduction of new crops. Evidence of husbandry changes that might have led to improvements in crop yields is more problematic because it is also necessary to demonstrate the connections between such husbandry changes and changes in yields. We can, however, be fairly certain that the 'limiting factor' to cereal growth before the early nineteenth century was the supply of nitrogen.[41] Thus evidence of husbandry changes that would have made more nitrogen available to cereals should provide some support for the view that yields were rising.

In fact it is possible to identify many strategies adopted by farmers which would have made more nitrogen available to cereals, although of course farmers would not have interpreted their actions in these terms. The ploughing of permanent pastures had the effect of exploiting reserves of nitrogen which may have been responsible for raising yields in some areas in the late sixteenth century as the initial consequence of a switch to convertible husbandry.[42] Better use was made of existing manures, and, from the mid-seventeenth century, greater use of new manures was advocated including seaweed and human waste.[43] Apart from adding nitrates to the soil farmers also adopted strategies that would have made more soil nitrogen available to cereals by improving soil structure through better drainage, and reducing acidity through the addition of lime and marl.[44] But by far the most important change was the introduction of clover. It is likely that the cultivation of clover in the late eighteenth and early nineteenth centuries increased the supply of nitrogen to English

[38] Campbell and Overton, 'New perspective on medieval and early modern agriculture', pp 38–105; Yelling, 'Changes in crop production in east Worcestershire'; J A Yelling, 'Probate inventories and the geography of livestock farming: a study of east Worcestershire, 1540–1750', *Trans Inst Brit Geogrs*, no 51, 1970, pp 111–26; Peter Edwards, 'The development of dairy farming on the north Shropshire plain in the seventeenth century', *Midland History*, 4, 1978, pp 175–89; Glennie, 'Continuity and change in Hertfordshire agriculture, I'; John Broad, 'Alternate husbandry and permanent pasture in the Midlands 1650–1800', *Ag Hist Rev*, 28, 1980, pp 77–89.

[39] Ann Kussmaul, *A General View of the Rural Economy of England, 1538–1840*, 1990.

[40] Campbell and Overton, 'New perspective on medieval and early modern agriculture', p 61. Evidence from elsewhere derived from the sources in note 37 and the tithe files.

[41] Robert S Shiel, 'Improving soil fertility in the pre-fertiliser era', in Campbell and Overton, *Land, Labour and Livestock*, pp 51–77.

[42] *Ibid*, pp 62–3.

[43] Donald Woodward, ''An Essay on Manures': changing attitudes to fertilization in England, 1500–1800', in John Chartres and David Hey, eds, *English Rural Society, 1500–1800: Essays in Honour of Joan Thirsk*, 1990, pp 251–78.

[44] Glennie, 'Continuity and change in Hertfordshire agriculture, II'; W M Matthew, 'Marling in British agriculture: a case of partial identity', *Ag Hist Rev*, 41, 1993, pp 97–110.

TABLE 4
Cereal yields in England, 1801–71 (bushels per acre)

	1801	*c 1836*	*1871*
Wheat	22	21	28
Barley	29	30	34
Oats	32	33	43
WACY[a]	17	18	25

[a] Weighted Aggregate Cereal Yield.
Counties used are: Bedford, Buckingham, Cambridge, Cornwall, Derby, Devon, Durham, Essex, Gloucester, Hampshire, Hereford, Huntingdon, Kent, Lincoln, Northumberland, Shropshire, Somerset, Stafford, Surrey, Sussex, Warwick, East Yorkshire, North Yorkshire, and West Yorkshire.
Source: see footnote 47.

farmers by over 60 per cent.[45] The first national figures for the acreage of clover are not available until the tithe files of the 1830s, but by then clover (and 'seeds') accounted for over 20 per cent of the arable area. For the two counties for which we have earlier comparative information, the precocious Norfolk and Suffolk, the figure of 3 per cent of the cropped area for the first three decades of the eighteenth century compared with 24 per cent in the 1830s suggests that the diffusion of the crop was very rapid in the years after 1740.[46] Table 4 gives yield figures for a selection of English counties after 1801 and shows that the major rise in yields comes after the 1830s (although the figures for the 1830s may be underestimates).[47]

V

Evidence about the productivity of crops is much more plentiful than evidence about the productivity of livestock, which is unfortunate since changes in livestock productivity were of more significance. The output of livestock products could have risen through two processes: first, through an increase in the number of livestock, implying an increase in the density of livestock per acre, implying in turn an improvement in fodder supplies; and second, through an improvement in the livestock themselves, so that animals produced more food in response to a given amount of fodder. In the one study available, for Norfolk, it has been found that livestock densities double in the seventeenth century, which suggests improvements in fodder output per acre.[48] This is associated with the breakdown of the rigid division between permanent pasture and permanent arable, and the development of convertible or ley husbandry. But establishing a grass ley was difficult ('to make a pasture breaks a man, to break a pasture makes a man'[49]) and the sowing of grass leys stimulated the search for appropriate grasses (or more specifically grass seed), which in turn stimulated the cultivation of clover and other so-called 'artificial' grasses from mid-century. In other areas of the country fodder supplies were increased through the floating of meadows, although the area of meadow capable of being developed in this way was necessarily limited by topography.[50] Important as these changes were, they do not compare with the extension of fodder supplies from the eighteenth century onwards.

Improvements in livestock themselves are also difficult to measure, despite the

[45] This figure is based on the work of G P H Chorley, 'The agricultural revolution in Northern Europe, 1750–1880: nitrogen, legumes and crop productivity', *Econ Hist Rev*, 2nd ser, XXXIV, 1981, pp 71–93, adjusted for England.

[46] Overton, 'Determinants of land productivity', p 306. Figures for Norfolk alone are shown in Table 3.

[47] For 1801 the yields are from Turner, 'Agricultural productivity in England in the eighteenth century', pp 489–510. See footnote 33 for the 1830s. For 1871 the figures are from P G Craigie, 'Statistics of agricultural production', *Jnl Roy Stat Soc*, 46, 1883, pp 1–58 reporting a survey by the *Farmer and Chamber of Agriculture Journal*. The Weighted Aggregate Cereal Yield is defined as:

$$Y = \sum (y_i \cdot p_i / p_w \cdot a_i / \sum a_i)$$

where Y is weighted yield, y_i is the yield of crop i in bushels per acre, p_i is the price of the crop per bushel, p_w is the price of wheat per bushel, a_i is the acreage under crop i.

[48] Mark Overton and Bruce M S Campbell, 'Norfolk livestock farming 1250–1740: a comparative study of manorial accounts and probate inventories', *Jnl Hist Geog*, 18, 1992, pp 377–96.

[49] H I Moore, *Grassland Husbandry*, 3rd edn, 1946, p 17; see also Allen, *Enclosure and the Yeoman*, pp 126–8.

[50] G G S Bowie, 'Watermeadows in Wessex: a re-evaluation for the period 1640–1850', *Ag Hist Rev*, 35, 1987, pp 151–8.

din of propaganda from a few very successful livestock breeders in the eighteenth century, and a growing volume of evidence of the rapid spread of new livestock types. In Norfolk the traditional sheep breed was largely replaced by Southdowns, Leicesters, and cross-breeds in the first quarter of the nineteenth century, and other evidence again suggests that breed improvements were only of major significance from the late eighteenth century onwards.[51] For cattle the major improvement was the development of the Shorthorn, but again the chronology is similar: the breed is developed towards the end of the eighteenth century and only becomes dominant by the middle of the nineteenth century.[52]

What impact these breed changes had is hard to observe directly. However, estimates of the volume of output of animal products show a two-and-a-half-fold increase between 1700 and 1850, yet the number of animals does not seem to have increased very much.[53] This suggests considerable improvement in the productivity of livestock (in terms of output per animal). This was partly due to improvements in fodder, partly due to breed changes, and partly due to an increased turnover of animals. Gregory King estimated that, in the late seventeenth century, less than one-fifth of the nation's cattle stock was slaughtered each year, whereas around the turn of the nineteenth century it was about a quarter, implying a 25 per cent improvement in supply, irrespective of any change that may have taken place in animal weights.[54]

TABLE 5
Ratios of animal and animal product prices (1550–1750 = 100)

Period	*Cattle/ Beef*	*Sheep/ Mutton*	*Sheep/ Wool*	*Swine/ Cattle*
1560–09	104	–	83	63
1610–59	110	80	83	86
1660–09	99	84	85	121
1710–59	87	141	155	147

Sources: see footnote 55.

Another indirect measure of increases in the output of livestock products per animal is given in Table 5. The table compares the price of livestock with the price of livestock products and thus gives an indication of the output per animal (the price of cattle divided by the price of beef per pound, for example, should give some indication of the number of pounds of beef per animal). Unfortunately the data in Table 5 can only be taken as far as 1760 after which no available series of livestock prices is extant.[55] For what they are worth the figures suggest a slight fall in the productivity of cattle between the mid-sixteenth and the mid-eighteenth centuries, but an increase for both mutton and wool of some 78 per cent during the first half of the eighteenth century, in comparison with the preceding century. It is also evident that the price of pigs relative to cattle had been increasing continuously since the sixteenth century: in the second half of the sixteenth century seven pigs were equivalent to one cow, by the mid-eighteenth century the number had reduced to three.

[51] Peter Wade-Martins, *Black Faces: A History of East Anglian Sheep Breeds*, Ashford, 1993; J R Walton, 'The diffusion of improved sheep breeds in eighteenth- and nineteenth-century Oxfordshire', *Jnl Hist Geog*, 9, 1983, pp 175–95.

[52] J R Walton, 'The diffusion of the improved Shorthorn breed of cattle in Britain during the eighteenth and nineteenth centuries', *Trans Inst Brit Geogrs*, new ser, 9, 1984, pp 22–36.

[53] See footnote 24 for sources for the calculation. In terms of 1850 prices the output of meat and dairy produce rose from £18.921 million in 1700 to £51.840 million in 1850.

[54] Thirsk and Cooper, *Seventeenth Century Economic Documents*, p 783; Holderness, 'Prices, productivity and output', p 157.

[55] Prices are from W Beveridge, *Prices and Wages in England from the Twelfth to the Nineteenth Century: Vol I Price Tables: Mecantile Era*, 1939, pp 144–7 (for mutton at Eton, 1600–1840) and pp 209–10 (for beef at Charterhouse, 1713–1830); J E T Rogers, *A History of Agriculture and Prices in England*, Vol IV, 1882, p 333; Vol V, 1887, pp 347–53, Vol VII, 1902, p 284 (for beef 1562–1712 at Cambridge); P J Bowden, 'Statistical appendix', in Thirsk, *Agrarian History of England and Wales, IV*, pp 839–45; *idem*, 'Statistical appendix', in Thirsk, *Agrarian History of England and Wales, V, Part II*, pp 843–6 (for wool 1500–1749); B R Mitchell and P Deane, *Abstract of British Historical Statistics*, 1962, pp 494–5 (for wool 1750–59). Livestock prices from some 20,000 probate inventories for Durham, Hertfordshire, Lincolnshire, Norfolk, Suffolk, and Worcestershire are also used.

These findings prompt many questions, not least about the appropriateness of the method. But if they are broad indications of trends in output per animal then improvements in wool and mutton yields take place before the breed developments of the late eighteenth century and therefore presumably must reflect improvements in fodder supplies and in the management of sheep flocks. Yet the lack of change in the ratio of beef and cattle prices would suggest that no significant improvements in fodder supplies were having an effect here. The rise in the value of pigs relative to cattle suggests that pigs were increasing in size. Pigs respond well to increased feeding and can eat a wide range of products. It has been suggested that during the early modern period there was a growing tendency for pigs to be housed and fed on household waste, rather than rooting freely in woodlands, a suggestion corroborated by the evidence of Table 5.[56]

VI

The discussion hitherto has been concerned with output and the productivity of land. Information on the productivity of labour is more difficult to produce. Although sources are available from which 'bottom up' estimates of labour productivity can be calculated for individual farms, very few such calculations have been made. In their absence the best estimates of labour productivity available at the moment divide the indices of output already discussed by the number of workers in agriculture (Table 1). The difficulties of estimating employment levels before the first census with appropriate information (in 1831) necessitates using a rather crude indicator of those working in agriculture which is the size of the 'rural agricultural population' as estimated by Wrigley for a series of dates back to 1520.[57] Interpretation of the trend in labour productivity based on the proportion of the population 'working' in agriculture is difficult because such estimates ignore the amount of time workers actually spent working, and the extent to which women and children were actively working on the land. Thus the slow growth in labour productivity of 0.15 per cent per annum over the 150 years between 1520 and 1670 may be illusory if on average each worker was working for more hours a year in the mid-seventeenth century than they had been in the mid-sixteenth century. If this was the case (and a number of factors, including the reduction in religious holidays with the Reformation, suggest that it was[58]) there may well have been a *fall* in labour productivity during the long sixteenth century. There is less doubt, however, that a sustained increase in labour productivity was underway from around the mid-seventeenth century, at around 0.45 per cent or higher per annum, and that from 1700 to 1850 labour productivity doubled.

VII

In the absence of any detailed studies of the determinants of labour productivity at local level we are left with a string of untested hypotheses as to why this growth in labour productivity took place. The increases in output per acre already discussed played a part in increasing labour productivity but they were unlikely to have been the major factor. While some agricultural operations required the same labour input irrespective of crop yields, such as ground preparation, many were directly proportional to yield such as threshing and to a slightly lesser extent harvesting. Thus

[56] J Wiseman, *A History of the British Pig*, 1986, pp 8–21.

[57] E A Wrigley, 'Urban growth and agricultural change: England and the Continent in the early modern period', in *idem*, *People, Cities and Wealth: The Transformation of Traditional Society*, Oxford, 1987, p 170.

[58] W G Hoskins, *The Age of Plunder*, 1976, pp 108–11.

higher yields inevitably meant more labour was required unless harvesting or threshing technology changed. The list of possible explanations for improvements in labour productivity is long and growing, but it may be divided into four categories: changes in labour practices, improvements in the amount of energy available in farm work, increases in farm size, and changes in employment practices. Little mechanization of farming took place before the mid-nineteenth century, but there were two changes in farming practice that may have been of some significance to labour productivity. The first was the introduction of improved ploughs in the eighteenth century, particularly the Rotheram plough which reduced the labour requirement from both men and horses during ploughing.[59] It is also likely that labour was saved through changes in harvesting techniques from the mid-eighteenth century but the chronology of the change from sickle to scythe is in some dispute.[60]

Hunt has suggested that regional variations in labour productivity in the mid-nineteenth century may have been due to the inadequate diets of labourers in some areas.[61] Poor diets reduce the energy for farm work; thus low labour productivity might have been associated with nutritional deficiency. This argument could be applied chronologically as well as spatially. Thus the apparent upsurge in labour productivity from the mid-seventeenth century might be linked to the relatively low price of foodstuffs and the rise in real wages, especially during the first three decades of the eighteenth century. The substitution of animal for human labour and effort has recently been suggested by Wrigley as another potential source of rising labour productivity. He shows that pro rata English farmers had two-thirds as much animal power at their disposal than their French counterparts at the turn of the nineteenth century. Thus the amount of horsepower available for each man employed in agriculture is estimated to have risen by 63 per cent between 1700 and 1850.[62] This hypothesis is attractive for agriculture makes tremendous demands for energy, and we have evidence from Norfolk that the supply of energy in the form of beasts of traction was increased during the early modern period. Not only was the number of beasts increasing from the Middle Ages, but the more efficient horse was replacing the ox.[63] A similar pattern existed in other counties although the chronology was usually much later.

The link between labour productivity and farm size is simply that larger farms appear to have employed fewer people per acre, so that if average farm size increased, the average number of employees would decrease. Allen argues that this was the case from the mid-seventeenth century using evidence on the relationship between employment and farm size from data compiled by Arthur Young in the 1760s, applied to a new body of data on farm size in the south Midlands. These farms were growing in size during the eighteenth century and by implication would have been using less labour per acre.[64] On the other hand, evidence from Belgium and Ireland in the nineteenth century suggests that small farms could be more efficient in their use of labour than larger ones.[65]

[59] G Marshall, 'The 'Rotheram' Plough: a study of a novel 18th century implement of agriculture', *Tools and Tillage*, III, 1978, pp 149–67.

[60] E J T Collins, 'Harvest technology and labour supply in Britain, 1790–1870', *Econ Hist Rev*, 2nd ser, XXII, 1969, pp 453–73; J A Perkins, 'Harvest technology and labour supply in Lincolnshire and the East Riding of Yorkshire 1750–1850, part one', *Tools and Tillage*, 3, 1976, pp 46–58.

[61] E H Hunt, 'Labour productivity in English agriculture, 1850–1914' *Econ Hist Rev*, 2nd ser, XX, 1967, pp 285–8.

[62] E A Wrigley, *Continuity, Chance and Change: The Character of the Industrial Revolution in England*, 1988, pp 35–45; *idem*, 'Energy availability and agricultural productivity', in Campbell and Overton, *Land, Labour and Livestock*, pp 323–39.

[63] Campbell and Overton, 'Norfolk livestock farming', p 383.

[64] R C Allen, 'The growth of labour productivity in early modern English agriculture', *Explorations in Econ Hist*, XXV, 1988, pp 117–146; *idem*, *Enclosure and the Yeoman*, pp 211–27.

[65] P Solar and M Goossens, 'Agricultural productivity in Belgium and Ireland in the early nineteenth century', in Campbell and Overton, *Land, Labour and Livestock*, pp 372–6.

The final category, changes in employment practices, covers many possible factors. Evidence is available of changes in employment relationships, but the effect of these on labour productivity (as opposed to other effects) has not really been explored. Some changes in employment practices from the eighteenth century could have increased labour productivity derived by using the proportion of the labour force as the denominator in the calculation, but would have made little difference to labour productivity calculated using output per man hour. The duration of many labour contracts was reduced from the year, to the week, or sometimes to the day; often the process went further and workers were paid by piecework rather than a flat rate.[66] Thus proportionately fewer agricultural workers would be needed. This accords with the decline in the incidence of farm servants, since servants were hired by the year on an annual contract.[67] Furthermore, the introduction of turnips and clover made demands for labour at periods when they had otherwise been low. Thus while the extra output from these crops would appear in the numerator of the labour productivity calculation, the extra labour input would not be included in the denominator if it was being measured in terms of the proportion of the work-force employed in agriculture rather than as the number of hours worked.[68]

Other changes in employment are more imponderable. Hunt has also argued that some farmers were more concerned with providing work than making efficient use of labour.[69] On the other hand improvements in farming skills and farm management undoubtedly took place from the eighteenth century, but are extremely difficult to pinpoint. The supply of farming books increased from the mid-seventeenth century but while some of these advocated best-practice techniques, others were quite bizarre in their recommendations. The provision of formal agricultural education in England did not occur until the nineteenth century, but that is not to say that levels of skill and management were not improving. By the nineteenth century English farmers had a growing range of literature advising them how to farm more profitably, and how to use labour more efficiently.[70]

VIII

The evidence reviewed so far points towards the same conclusion. If the criteria for an 'agricultural revolution' are taken to be unprecedented changes in output and in the productivities of land and labour, then it is the period after the mid-eighteenth century that emerges as having experienced such a revolution. It was during the eighteenth century that population was able to break through the ceiling of 5.5 million, that crop yields made a sustained improvement on medieval levels, and land and labour productivity were rising together. There were some productivity improvements in the seventeenth century, especially with livestock, but they cannot compare with the magnitude of changes in the eighteenth century. There were also some important changes in agricultural practice before the eighteenth century. Production was intensified from the sixteenth century, and was becoming more

[66] A Armstrong, 'Labour I: rural population growth, systems of employment, and incomes', in Mingay, *Agrarian History of England and Wales, VI*, pp 671–95.

[67] A Kussmaul, *Servants in Husbandry in Early Modern England*, 1981.

[68] C P Timmer, 'The turnip, the new husbandry, and the English agricultural revolution', *Quarterly Journal of Economics*, LXXXIII, 1969, pp 375–95.

[69] Hunt, 'Labour productivity in English agriculture', pp 288–90.

[70] K Tribe, *Land, Labour and Economic Discourse*, 1978, pp 53–79; H S A Fox, 'Local farmers associations and the circulation of agricultural information in nineteenth-century England', in *idem* and R A Butlin, eds, *Change in the Countryside: Essays on Rural England, 1500–1900*, Inst Brit Geogrs Special Publ, X, 1979, pp 43–63; J D Sykes, 'Agriculture and science', in G E Mingay, ed, *The Victorian Countryside*, 2 vols, 1981, vol I, pp 267–70; K Hudson, *Patriotism with Profit: British Agricultural Societies in the Eighteenth and Nineteenth Centuries*, 1972, pp 113–29; N Goddard, 'Agricultural literature and societies', in Mingay, *Agrarian History of England and Wales, VI*, pp 331–83.

regionally specialized in the seventeenth, but it was not until after 1750 that high yielding fodder crops were grown on a substantial scale enabling intensification through a reduction in fallow and a massive increase in the supply of nitrogen to farmland.

The arguments for an 'agricultural revolution' commencing in the sixteenth century therefore fail to carry conviction. There is some justification in the claim that breaking the distinction between pasture and arable is revolutionary, or at least is a change of potentially revolutionary significance, although the evidence on which the claim is based is open to varying interpretations. The ploughing up of pasture land can also be interpreted as a desperate attempt by farmers to cash in on reserves of nitrogen to produce as much grain as possible in the face of overwhelming demand. Putting land back under a temporary ley would be much more difficult, and it was not until clover and other grass seeds became more widely available in the eighteenth century that true convertible husbandry could take place. For all his footnotes Kerridge's arguments are not persuasive, and the moderate rise in yields from the mid-sixteenth century is most likely the consequence of increased labour inputs, and labour productivity was probably falling from the mid-sixteenth to the mid-seventeenth centuries. Coupled with evidence of widespread reclamation and the halt to population growth in the mid-seventeenth century this period is more suggestive of a Malthusian check than an agricultural triumph.[71]

Nor is there any evidence to suggest that changes in the century after the Restoration were of more significance than those that were to follow. English agriculture had achieved an export surplus by 1750, and output was growing at a faster rate than was population. Jones argued that the period saw a rise in crop yields through the introduction of cost-cutting innovations, and while his arguments are consistent and coherent, elegance is no substitute for evidence.[72] New crops were certainly being grown, although both the scale and manner of their cultivation suggest their impact on output and productivity was minimal until after 1750. It is true that in some areas crop yields may have been rising although they were still within medieval norms until the eighteenth century, but rises in yields were not yet associated with the introduction of new crops.[73] In fact the changes of most significance were concerned with livestock husbandry: the striking evidence from national prices suggests improvement in the yield of both wool and mutton during the first half of the eighteenth century, although cattle appear to be producing no more meat. For Norfolk, there is also the remarkable doubling of livestock densities in the seventeenth century reflecting an improvement in fodder supplies which is less conspicuous than the innovation of turnips and clover. Also of likely significance for this period is the probability of a steady improvement in labour productivity after 1670, but this is a phenomenon which has

[71] R S Schofield, 'The impact of scarcity and plenty on population change in England, 1541–1871', in R I Rotberg and T K Rabb, eds, *Hunger and History*, 1985, pp 67–94; Campbell and Overton, 'New perspective on medieval and early modern agriculture', pp 44–5, 95–99.

[72] Most of Jones' arguments are supported by scattered instance from farm accounts and contemporary literature. A major assumption, that the terms of trade favoured livestock, is an exaggeration since terms of trade moved only slightly in favour of livestock and could have been more than offset by government inducements to maintain arable cultivation, together with the development of both markets and new ways of marketing grain: E L Jones, *Agriculture and the Industrial Revolution*, Oxford, 1974, p 72; John, 'Agricultural productivity and economic growth', pp 19–25; M W Flinn, 'Agricultural productivity and economic growth: a comment', *Jnl Econ Hist*, XXVI, 1966, pp 93–8; Mark Overton, 'An agricultural revolution, 1650–1750', in *idem*, E J T Collins, M E Turner and D N McCloskey, *Agricultural History: Papers Presented to the Economic History Society Conference*, Canterbury, 1983, pp 6–7; Patrick O'Brien, 'Agriculture and the home market for English industry, 1660–1820', *Eng Hist Rev*, C, 1985, pp 773–800; but see also the comments of Glennie, 'Continuity and change in Hertfordshire agriculture, II', pp 157–8.

[73] Overton, 'Diffusion of agricultural innovations'.

been omitted in accounts of early modern agriculture.

While Jones' arguments are not backed up by sufficient evidence, Clark's recent dismissal of an 'agricultural revolution' taking place from the eighteenth century stems from a rejection of conventional historical evidence in favour of deductions based on economic theory. He prefers to infer agricultural developments from a calculation of productivity based on a comparison of input and output prices, which fails to reveal much productivity change. Although this exercise is based on (unspecified) economic assumptions which may be inappropriate for the eighteenth- and early nineteenth-century economy, and uses price data which may have a regional bias, Clark chooses to accept its results: in short he relies on economics not evidence.[74]

Trouble with evidence also undermines Allen's recent claim that 'the yeoman farming system of seventeenth-century England produced a revolution in corn yields'.[75] The suspicion that this might be a rather sweeping generalization is raised when it is realized that the evidence for this statement is based on yields in part of Oxfordshire, and confirmed when that evidence is examined in detail. The yield statistics for wheat derive from 28 plots of ground in part of Oxfordshire over a period of 177 years from 1550–1727 with each observation coming from a different plot of land. Moreover, the estimation of yields on these plots is problematic and particularly so when compared to later yields from different sources.[76] It may be that the trend of yields in Oxfordshire is correct, for there were undoubtedly regional variations in yield trends, but unlike, say, Glennie's work on Hertfordshire, where yields were rising as a consequence of better ground preparation, Allen adduces little evidence as to why this should be the case apart from an assertion that wheat varieties were being improved to yield more highly.[77]

IX

Allen also strongly supports another revisionist argument: that enclosure had little effect on productivity change. From the early 1960s a number of historians began to argue that enclosure was not a pre-requisite for husbandry innovations and that open-field farmers were quite capable of introducing both turnips and clover to improve their output and productivity.[78] Thus they argue that agricultural improvements of revolutionary significance were possible in the open fields before the parliamentary enclosure movement after 1750. Allen develops this point by arguing that for the south Midlands yield increases were not associated with enclosure. Indeed he has to do this to sustain his argument that crop yields rose in the seventeenth century rather than in the eighteenth. It would seem unfortunate therefore that he finds abundant evidence of crop innovation in enclosed parishes ('enclosed farms were the most progressive'[79]), since such innovation might be expected to lead to greater productivity. The evidence for innovation comes from parish by parish agricultural censuses for Rutland and Huntingdon compiled by Parkinson and published in his *General Views* of those counties.[80] Undaunted, however, Allen argues that

[74] Clark, 'Agriculture and the industrial revolution', pp 242–9; see also C Knick Harley, 'Reassessing the industrial revolution: a macro view' in Mokyr, *The British Industrial Revolution*, pp 191–7.

[75] Allen, *Enclosure and the Yeoman*, p 208.

[76] The yield of barley is based on 35 different plots of ground: R C Allen, 'Inferring yields from probate inventories', *Jnl Econ Hist*, XLVIII, 1988, pp 117–25; Mark Overton, 'Re-estimating crop yields from probate inventories', *Jnl Econ Hist*, L, 1988, pp 931–5.

[77] Overton and Campbell, 'Productivity change in European agricultural development', pp 38–41; Glennie, 'Continuity and change in Hertfordshire agriculture, II', pp 150–2; Allen, *Enclosure and the Yeoman*, pp 206–7; Overton, 'Determinants of land productivity', p 290.

[78] Jones, 'Agriculture and economic growth in England', p 8; Kerridge, *Agricultural Revolution*, pp 19–20.

[79] Allen, *Enclosure and the Yeoman*, p 112.

[80] R Parkinson, *A General View of the Agriculture of the County of Rutland*, 1808; *idem*, *A General View of the Agriculture of the County of Huntingdon*, 1811.

despite this evidence of innovation neither crop yields nor total agricultural output were higher in enclosed villages.

Why did innovation take place if neither yields nor output increased? This is a strange finding which flies in the face of both theoretical and empirical evidence of a link between these crops and increases in output.[81] Parkinson reports acreages of arable, meadow and pasture, but not the acreages under particular crops, which Allen deduces from somewhat ambiguous evidence of crop rotations. Nor does Parkinson record livestock output, and Allen is therefore forced into the hazardous procedure of estimating the output of livestock products from the number of animals. Grain yields are recorded directly, and Allen maintains they show little difference between parishes which are open and those which have been enclosed, especially for wheat, a finding which conflicts with Yelling's opinion of Parkinson's data.[82]

The most important problem, however, is that Allen is not comparing the situation before and after enclosure in the same parishes, but is comparing different parishes in the first decade of the nineteenth century. Most of the enclosure that had taken place by this time had resulted in the conversion of arable to pasture and was not designed to increase arable production. Much enclosure was still to come and was to be more geared towards improving grain output. Thus it might be that those arable open-fields remaining when Parkinson's census was taken were more productive than those that had been enclosed, since it is reasonable to assume that the least profitable arable open fields are the most likely to have been enclosed for pasture. Contemporary evidence for Rutland and Huntingdonshire based on a survey of incumbants and comparing the *same* parishes before and after enclosure gives a different picture.[83] Following enclosure in Huntingdonshire sheep numbers are reported as rising in 14 villages and falling in 3, and in Rutland rising in 8 villages and falling in none; cattle numbers are reported to rise in 10 villages and fall in 3 in Huntingdonshire, and in Rutland to increase in 5 villages and remain constant in 1.[84] This contrasts with Allen's conclusions from his manipulations of Parkinson's data that a decline in the number of animals took place 'after enclosure', and that 'enclosure... did not lead to more livestock' based on the *cross sectional* comparison of open and enclosed parishes.[85]

These comparisons around 1800 are mostly between parishes which had been enclosed for pasture and arable open-field parishes. Another kind of enclosure involved the reclamation of light-land lowland wastes for arable land. An early example of such an enclosure was at Canwick, in Lincolnshire, and although merely one example it is instructive. Following enclosure wheat yields rose by only 10 per cent, but barley and oat yields by 40 and 78 per cent respectively. The most significant change, however, was with livestock; the numbers of sheep rose by 33 per cent and the value of their output increased by an astonishing 590 per cent. This was because flocks kept only for folding on the arable and for their wool were replaced by flocks of improved breeds of sheep which were better fed with fodder crops and kept primarily for their mutton.[86] Wheat yields are but one indicator of land productivity and given the widespread introduction of fodder crops may not be

[81] Shiel, 'Improving soil fertility'; Chorley, 'Agricultural revolution in Northern Europe'; Overton, 'Determinants of land productivity', p 314.

[82] J A Yelling, *Common Field and Enclosure in England 1450–1850*, 1977, p 204.

[83] *General Report on Enclosures drawn up by order of the Board of Agriculture*, 1808.

[84] *Ibid*, p 254.

[85] Allen, *Enclosure and the Yeoman*, pp 114, 117–8.

[86] *General Report on Enclosures*, pp 270–1. For the economics of different types of enclosure see *idem*, pp 286–9; Wade-Martins, *Black Faces*.

the most appropriate index of land productivity.

This is not to argue that agricultural improvement was impossible without enclosure. New methods were introduced within open field systems and groups of villagers could agree to change their ways within the confines of common property rights. But enclosure accelerated the process dramatically, gave immediate opportunities to make new profits, and the transformed landscapes it produced were a constant reminder that a new agricultural order was in place.[87]

X

In the face of so much evidence to the contrary why is it that so very few historians now credit the agricultural developments in the century after 1750 as being revolutionary? Undergraduate historians often adopt an uncritical tendency to believe that 'newer is truer', that the more recent references on (or not on) their reading list are more likely to provide them with a more 'correct' answer. This is associated with an implicitly Whiggish notion of progress applied to the writing of history; that for some reason today's histories necessarily improve upon those of the past. It would be unfortunate if this undergraduate ideology persisted and became embodied in academic publication for it is clearly fallacious. The range and quality of historical evidence can improve, as can historians' techniques for processing that evidence; but, ultimately, the issues for historical judgement remain the same: what is the quality of the evidence available and to what extent does answer the questions at issue.

The verdict of this paper, that the agricultural revolution did not get underway until the eighteenth century, echoes the views of an earlier generation of historians although it is based on such new evidence. That evidence overwhelmingly favours the century after 1750 as the period of most rapid and fundamental change in output and productivity, which were associated with equally unprecedented and fundamental changes in husbandry.

[87] Devine, *Transformation of Rural Scotland*, pp 51–2.