Technological Change in Medieval England: A Critique of the Neo-Malthusian Argument[1]

HARRY KITSIKOPOULOS

Clinical Assistant Professor, Department of Economics, New York University

THE SO-CALLED BRENNER DEBATE was a rare intellectual spark in the long historical tradition, going back to Marx, that seeks to discover and reconstruct the main variables behind the prolonged decay and collapse of feudalism. The most valuable contribution of the debate was that it stimulated interest from scholars of various disciplines and it acted as a powerful spur leading to a number of studies that, in turn, enlarged the ongoing research program. Its most objectionable inadequacy, in the view of this author, was the failure of the various contributors to assign a more prominent place to the role of technical change in conditioning the patterns of economic growth during the period 1200–1500. An overview of the evidence will show that the diffusion of medieval technologies unfolded in a rich mosaic of manifestations and, therefore, warrants more than the incidental references to it made by the various participants in the debate.[2]

This paper is divided into six sections. First, it provides a critical summary of the way M. M. Postan and his followers perceived the development of technical change and the significance they ascribed to it in the context of the radical transformations that took place during

[1] An earlier version of this article was presented at the annual meeting of the Society for the History of Technology, Detroit, October 1999. The author is heavily indebted to his dissertation supervisor, the late Professor David M. Gordon, whose influence extends far beyond this paper. John Langdon, Ron B. Thomson, and anonymous referees contributed valuable comments on the content and style of an earlier draft; the usual disclaimer applies.

[2] The debate started with Robert Brenner's article "Agrarian Class Structure and Economic Development in Pre-Industrial Europe," published in *Past and Present* 70 (February 1976); it was followed by a response from Postan and Hatcher in issue 78, and by other contributions by Croot and Parker, Wunder, Le Roy Ladurie, Bois, Hilton, Cooper, Klima, and another response by Brenner, thus extending the debate to 1982. Subsequently, the various contributions were published as a collection of essays entitled *The Brenner Debate: Agrarian Class Structure and Economic Development in Pre-Industrial Europe*, ed. T.H. Aston and C.H.E. Philpin (Cambridge, 1987); my subsequent citations of particular articles refer to this volume.

this period. It will be argued that Postan's perspective encapsulates a strikingly static perception of medieval technology and, as a result, reduces it to an irrelevant datum when he discusses the system's dynamics. The second section will seek to challenge this view by laying the empirical foundation of my argument in the form of an overview of productivity yields recorded across England during the aforementioned period. If medieval technology was static, so ought to have been crop yields, since the two are locked into a cause-and-effect relationship. Nevertheless, Postan's perspective is not supported by the data, because they clearly reveal both temporal fluctuations and wide disparities across regional lines. The next two sections will attempt to establish a correlation between the unevenness of yields during the pre-plague period and the technological choices made by manorial officials.[3] The purpose of these sections is not simply to verify that productivity and growth levels emanate from the patterns of technological diffusion, but to categorize the various regions of the country based on their technological performance. The method that is used to assess these performances is to contrast the actual technical choices made in two broadly-defined regions with the "technological matrices" that were ideal given their particular ecological profiles. The degree to which the actual deviated from the ideal will not only put Postan's view of static technology to rest but, in addition, will press the need for an alternative model founded on entirely different assumptions and premises. At that point, the crucial question ought to be: what rendered some regions technologically more progressive than others?

The last two sections will address this issue by dividing the material into two periods preceding and following the great epidemic. The interpretation that will be provided is heavily indebted to Brenner. The main line of the argument is that feudal dynamics were determined by the contradiction, inherent in the system, between the need to balance the rates of productivity/output growth with the rate of demographic expansion, on the one hand, and the presence of a surplus-extraction mechanism that rendered this imperative virtually impossible; that is, because the appropriation of material and labor inputs convinced landlords that wealth accumulation could be obtained through political oppression, as opposed to improving their technological infrastructure. Of course, the degree of seigneurial power was not uniform across the country, which goes a long way in explaining the aforementioned regional differences in efficiency standards and productivity yields.

[3] The technological choices among peasant holdings will not be covered in this essay. This topic was explored in Harry Kitsikopoulos, "Standards of Living and Capital Formation in Pre-Plague England: a Peasant Budget Model," *Economic History Review* 53.2 (2000).

There is one element of Brenner's argument, though, that the present author finds insupportable by the empirical evidence, namely, that "class structures tend to be highly resilient in relation to the impact of economic forces; as a rule, they are not shaped by, or alterable in terms of, changes in demographic or commercial trends."[4] Instead, I will argue that the relationship between class structures and economic forces is occasionally interactive, as opposed to unidirectional, and that was particularly evident in the post-plague period.

* * *

The mainstream approach to medieval English agriculture was formulated by M. M. Postan and his followers, and came to be known in the literature as the Neo-Malthusian argument. Despite the objections of its main authors, it does bear a striking intellectual affinity to the Malthusian theory of population, as modified by the Ricardian theory of differential fertility and diminishing returns.[5]

In the Ricardian model land is treated as a productive factor that is fixed in supply, containing many pieces of land with a wide range of output capacities and locational characteristics that provide limited choices for alternative uses; perhaps most important of all, land is considered a non-reproducible factor. In essence, this is a theory of marginal productivity; it claims that productive agents will push the intensive and extensive margin of cultivation to the point where the value of the marginal product will be equal to the marginal cost, at which point the next piece will come into use. The least fertile land, whose product determines the market price, does not generate any rent and thus rent is not one of the components of market price; rent is generated proportionately in land of higher fertility, and takes the form of a residual. For Malthus it was an easy step to conclude—although it took more the form of an implicit assumption than a full-blown analytical scheme—that unchecked population growth would lead to the cultivation of additional, and poorer, pieces of land. Needless to say, this process is self-defeating because the supply of land is fixed.

Ricardo and Malthus presented to Postan and his followers an irresistible conceptual framework for interpreting the empirical evidence

[4] Brenner, "Agrarian Class Structure," 12.

[5] The term Neo-Malthusian will be used in this paper, despite its inadequacy, in order to avoid further confusion. The synthesis that follows is based on my reading of David Ricardo, *On the Principles of Political Economy and Taxation*, ed. Piero Sraffa (Cambridge, 1951), especially chapters 2, 3, 24, 26, 32, and of Malthus, *First Essay on Population* (London, 1926), 1–39; the two works were first published in 1817 and 1798 respectively. See also Mark Blaug, *Economic Theory in Retrospect* (Homewood, Ill., 1962), 61–63, 71–78, 81–85, 99–102.

concerning the state of medieval technology and the overall crisis of English feudalism. It is well known that by the very end of the thirteenth century population reached an unprecedented plateau and faced increasing constraints with regard to its food supply, which was reflected in static or even declining yields. The "truly historical, time conditioned" cause of this chain of events, Postan suggests, was the exhaustion of the soil after the centuries-long process of uninterrupted cultivation, especially within the heartland of English manorialism. In this context, a prominent role was played by the inferior responses that producers used in addressing basic technical needs, as manifested in the "low quality of the seed, the shallow ploughing, the absence of proper underdraining of the heavier and more fertile soils, the inability of the fallowing routine to deal properly with weeds, and . . . the insufficiency of manure."[6] The extension on the margin of cultivation was the only viable response left, a fact that Postan was the first to point out and systematically describe.

But what precise role does technological change play in these narratives? For Ricardo, along with Malthus and other contemporary writers such as West and Torrens,[7] the answer was an obvious one: the progress of technology in agriculture could not compare with the impressive achievements of the division of labor and the use of machinery in industry, and thus it was incapable of reversing the progressive deterioration of land fertility. Technical change in their model is nearly static and, in essence, is merely an assumption, a given, playing no role in determining the direction of systemic dynamics and the end result of the accumulation process.

Notwithstanding the complex details of late feudal England, Postan's theoretical account is strikingly similar to its classical predecessor, especially when it comes to the absence of a cumulative process of *invention*; in his words, this absence was reflected in the "insufficient supply of new technological possibilities."[8] The development of new techniques "remained remarkably static for the whole of the Middle Ages," and he adds that, throughout the period, their importance was "not quite so fundamental as it is sometimes assumed."[9] The lack of inventions can be amply clarified by the invest-

[6] M. M. Postan, *The Medieval Economy and Society* (Berkeley, 1973), 62.

[7] Relevant quotations from the writings of West and Torrens, along with critical comments, can be found in Blaug, *Economic Theory in Retrospect*, 71–73.

[8] M. M. Postan and John Hatcher, "Population and Class Relations in Feudal Society," in *The Brenner Debate*, ed. Aston and Philpin, 77.

[9] M. M. Postan, *Essays on Medieval Agriculture and General Problems of the Medieval Economy* (London, 1973), 17.

ment behavior of the upper classes.[10] Landlords spent modest portions of their revenues on building barns or adding to their livestock wherever the territorial balance of arable land and pasture allowed and, at best, supplemented these small investments with administrative innovations, better marketing of the produce, and slight alterations in the rotation patterns of crops. Efforts like these would increase the output of individual manors, but could provide little leverage in reversing the imbalance between demographic growth and static food supplies for the country as a whole.

Those limited investments suggested to Postan not only a qualitatively poor technical base, but also the failure to utilize already existing techniques—that is, an imperfect process of technical diffusion. Drawing his evidence again from the behavior of the ruling class, he noted the inevitable extension of the margin of cultivation, as demonstrated by the large reclamation movement, a form of investment that adds precious little to the long-term productive capacity of a society. Postan observes that this apparent miscalculation made sense from the point of view of landlords because the size of their holdings was the main indicator of their hierarchical status and could lead to a series of privileges such as the acquisition of a standing army, religious salvation through land endowments, and powerful alliances with other members of the baronial class through the marriage of family members.

In general, Postan's account points to the lack of any new independent inventions and the underutilization of existing technology, attributing these to the value system of the ruling class. The impression we are left with is that medieval technological changes were external and minor "injections," causing only temporary disturbances in production functions and, in the end, failing to lead England on a path of dynamic and cumulative adjustment. The pace of technological change failed to catch up with population growth, thus leading to the unfolding of the Malthusian scenario.

There is one last point that needs to be emphasized. Its relevance will become apparent when we evaluate Postan's theory. From the Ricardian proposition that rent does not enter into price, it follows that the existence of landlords is entirely irrelevant to the outcome of his gloomy scenario. Even if landlords decide suddenly to give up their property rights over the land, and withdraw into the realm of social irrelevance, the mechanism that reproduces the unequal race between human procreation and food supplies would still be left intact; the price of agricultural products and the marginal cost would remain the

[10] Postan's, along with Hatcher's, view on the investment behavior of landlords is summarized in their "Population and Class Relations," 77–78.

same, as well as the pattern of demand (since Ricardo considered the demand of corn to be inelastic). The key element in this scheme is the insufficient generation of inventions. It follows that *the law of diminishing returns will work with iron necessity, regardless of any considerations about the class structure* of a society.

Overall, there is a compelling simplicity in this Neo-Malthusian model, with its mechanistic logic, which apparently succeeds in encompassing and simultaneously determining a whole array of variables. Based on the unequal rates of growth between output and population, and assuming technical change to be almost static, it explains the declining productivity of the land and leads to the two most basic predictions of the Ricardian model: (a) the rapid rise in food prices during the century preceding the Black Death; and (b) the proportional increase in rents and entry fines. Furthermore, if we extend our scope to the middle of the fourteenth century and thereafter, the model provides us with a reason for the onset of the crisis and disruption, and also the reversal of the pre-plague trends as reflected in stagnating or falling rents and food prices due to the alteration of the ratio between land and labor.

A closer examination of the Neo-Malthusian model, however, reveals discrepancies between the theory and the empirical evidence that has been produced, especially since the debate first took place. Technological change becomes implicitly a critical variable both in the classical account and in Postan's because, in the absence of an expanded foreign trade, it provides the only mechanism that can keep marginal revenue above marginal cost and thus prevent an economy from reaching its Malthusian ceiling.

Virtually every student of the period will agree with Postan that the performance of late feudal England in generating new technologies was very poor. But he never seriously asked, what prevented *the rapid and universal diffusion* of already existing technologies? The law of diminishing returns in agriculture has a logical appeal when we consider the case of two variable factors (capital and labor) exploiting a fixed quantity of a constant factor (land) under conditions of static technology. But there is no good reason why technological diffusion should operate under an equivalent law of diminishing or even constant returns, especially in a country such as medieval England.

The deficiency of the Neo-Malthusian model is particularly noticeable in its account of manorial estates, which are presented as backwaters in terms of their technological infrastructure. This notion seems to contradict more recent studies—their findings to be explored in following sections—that project multiple variations in terms of diffusion rates and, by extension, a wide range of productivity rates. The major-

ity of manorial estates did behave according to the Neo-Malthusian account, but there was also a progressive segment that did not conform to the norm. In terms of the former, it is true that the members of the ruling class shared a set of values that favored the ever-increasing acquisition of land and territorial expansion for the reasons Postan had mentioned. But why should this aim be promoted to the exclusion of investment "in depth"? Are these two ways of increasing wealth necessarily contradictory? The Neo-Malthusian historians failed to link the power of the manorial element in each locality with the pace of technological diffusion that was adopted, and to probe the potential of a cause-and-effect relationship between the two.

* * *

If the Neo-Malthusian argument is to be challenged, the criticism should not be directed at its logical coherence, since its conclusions do make sense given its assumptions and premises; instead, the real test is whether the argument's theoretical framework can encompass and interpret the existing empirical evidence. To begin with, if the slope of the population curve, and its impact on the extensive margin of cultivation, is the main determinant of feudal dynamics, it follows that efficiency standards ought to have declined as this curve went through its upward trajectory before the Black Death, followed by an efficiency improvement with the reversal of demographic trends after the great epidemic. Besides this temporal dimension, the argument ought to be judged from a regional perspective. If other factors, such as variations in the ecological and institutional profiles of the country, were of little or no significance to the long-term evolution of the system, then the periods of stagnation and recovery ought to have had a universal character.

The present section will put to test these two aspects of the Neo-Malthusian argument by looking at the level of productivity yields, which is the best indicator of efficiency standards, although yields are also affected, up to a point, by the natural fertility of the soil. The appendix presents a list of demesnial yields from already published material that classifies them into six sub-periods of fifty years each. One major caveat ought to be noted. The classification of few entries in a specific sub-period becomes problematic because the data provided by a particular author may extend into two or more sub-periods either as a matter of choice or as a result of the availability of existing data. In such cases I have chosen to include the particular sample in the sub-period to which the majority of the sample's data refer.

But for whatever the data are worth, some tentative generalizations can be made. Table 1 presents an intertemporal comparison of the

TABLE 1. An intertemporal comparison of demesnial yields

	Wheat	*Barley*	*Oats*	*Combined Average*
Period 1: 1200–49	3.80	4.40	2.60	3.60
Period 2: 1250–99	4.08	3.44	2.49	3.33
Period 3: 1300–49	3.89	3.79	2.40	3.36
Period 4: 1350–99	4.19	3.84	2.88	3.63
Period 5: 1400–49	3.66	3.76	3.22	3.54
Period 6: 1450–99	4.89	3.30	3.63	3.94

Sources: See Appendix.

average yields of the three main grains and a combined average per fifty-year period.[11] Looking at the behavior of individual grains does not always reveal neat patterns. Oat yields fall during the century leading to the Black Death and rise quite sharply thereafter. Barley yields fall during the period 1250–99, recover somewhat in the next fifty years, and stabilize at that level for the next century. Wheat yields are the most erratic of all, with no discernible pattern.

A clearer perspective can be drawn when we look at the combined average of the three grains. There seems to be a downward trend during the pre-plague period, as the Neo-Malthusian model predicts, exemplified in the case of manors with continuous data: Winchester (barley and oats), Westminster (wheat and oats), Cuxham (wheat), and Hinderclay (wheat). During the post-plague period—and discounting the years 1450–99 because the respective sample is not representative due to its small size and its concentration in manors located in fertile areas—we observe an initial recovery, followed by a new decline during the first half of the fifteenth century. These trends are evident in the case of Westminster (wheat and oats), Winchester (barley), and West Harling (barley). The post-plague behavioral pattern of yields justifies only partially the Neo-Malthusian account. Postan has argued that

[11] The appendix has been compiled on the basis of data cited in various studies that utilize bailiffs' account rolls from a number of demesnes across the country; a detailed description of how crop yields are calculated from these accounts is provided by J. Z. Titow, *Winchester Yields: a Study in Medieval Agricultural Productivity* (Cambridge, 1972), 5–9. Table 1 summarizes only yields per seed because yields per acre suffer as a credible indicator due to local variation in the sizes of bushels and acres. For instance, an acre in Devon was one-fifth larger than the statute one, and the local bushel was also larger than the standard one; see H.P.R. Finberg, *Tavistock Abbey: a Study in the Social and Economic History of Devon* (London, 1951), 113. The method of calculation adopted for Table 1 is as follows: each entry cited in the appendix was weighted for the number of demesnes it includes when calculating the average yields of wheat, barley, and oats for each sub-period of Table 1. Subsequently, a simple arithmetical average was used to calculate the so-called combined average from the values of each grain in a specific sub-period.

TABLE 2. A regional comparison of demesnial yields

	Wheat	*Barley*	*Oats*	*Combined average*
North/West	5.13	4.42	3.42	4.32
South/East	3.88	3.68	2.61	3.39

Sources: See Appendix.

yields "should have risen now that the poor and exhausted areas were withdrawn from cultivation" although "lands impoverished and abandoned in the previous generations were slow to recover or to return to cultivation."[12] Overall yields were certainly higher but, unlike the gradual but uninterrupted trend Postan predicts with the continuing demesnial shrinkage, yields behave somewhat erratically.

A second issue that ought to be addressed is whether the overall low level of yields is a reflection of a universal stagnation across the country, as the Neo-Malthusian argument implies, or whether there were in fact regional differences obscured by the overall figures. Table 2 clearly seems to suggest the latter.[13] The table divides the country into two broadly defined regions on the basis of certain ecological, institutional, and commercial differences that existed between them, differences whose precise nature will be specified in following sections. The weighted average of all entries from the southwestern peninsula, the West Midlands, and the northern counties is clearly superior for all grains, especially for wheat, compared with the levels achieved in the East Midlands and the counties along the southeastern coastline and in the central-south. Despite the intertemporal fluctuations, certain individual, or clusters of, manors within the former group achieved outstanding yields; notable examples are the manors of Cuxham, Ketton, Cowpen Bewley, Temple Thornton, to some extent those of Bolton Priory and, most important, a large number of manors in Devon and Cornwall. High yields are not lacking in the southern-eastern region of the country, in fact, we can point to several manors that performed quite well, such as those of Hinderclay, Stratton, Sevenhampton, Cringleford, Calthorpe, Silkstead, Farleigh Hungerford, Warboys, Ormesby, Apuldram, and a few others included within the cluster of a single estate. Nevertheless, there is a major proportional difference

[12] Postan, "England," in *The Cambridge Economic History of Europe* 1, *The Agrarian Life of the Middle Ages*, ed. Postan (Cambridge, 1966), 570.

[13] The same methodology of calculation was used as in Table 1. Namely, the values of the first three columns are the weighted averages of all entries referring to a regional group (inclusive of all sub-periods), whereas the values of the fourth column are simple arithmetical averages derived from the values of wheat, barley, and oats.

between the two regions: high yields in the large southern-eastern sample are far more scattered and sporadic compared with the north-west, since the latter included whole groups of manors that performed consistently well even in the context of a smaller sample.

In the end, the data fail to exhibit the type of uniform behavior predicted by the neatness of the Neo-Malthusian model. What led certain areas—notably Devon, Cornwall, and a certain number of demesnes along the southeastern (mainly East Anglia) and northeastern coastlines—to achieve such exceptional yields that do not fit quite well with the sweeping generalization of a universal stagnation? And why doesn't the initial recovery that was registered shortly after the Black Death follow an uninterrupted path leading eventually to some sort of agricultural revolution during the fifteenth century? These discrepancies between theory and facts seem to suggest that the former has to abandon monocausal explanations in favor of a multidimensional context of determination if it wishes to clarify the latter. The following sections will expand the range of potentially relevant explanatory factors arguing that temporal movements and regional variations in the ecological, institutional, and commercial profiles of the country produced a very complex and uneven process of technological diffusion whose primary manifestation is the level of productivity yields.

* * *

To understand the reasons behind the variation of yields we ought to start by looking at the unique ecological systems of each region. Edaphic and weather conditions affected the quantitative range of yields and defined the type of techniques that ought to have been used in each region in order to improve the productive potential of the soil. The variation of ecological features across the country implies that the lack of universality in the distribution of various technologies should not be seen as an index of deficiency; an ideal distribution does not imply a uniform diffusion.

The southern counties and the East Midlands were blessed with a relatively dry climate and expanses of lowland interrupted occasionally by gentle hills, attributes that are both very suitable for supporting a regime of mixed arable farming. But the most important feature of this region, in terms of defining its ecological profile and distinguishing it from the rest of the country, is the distribution of soil types.[14] Clay

[14] The description on the distribution of soil types across this region relies heavily on Eric Kerridge, *The Farmers of Old England* (London, 1973), 76–97. Supplementary material can be found in Alan Baker, "Field Systems of Southeast England," in *Studies of Field Systems in the British Isles*, ed. Alan Baker and Robin Butlin (Cambridge, 1973), 378–81; Bruce

deposits were present across large parts of the Midland plain, in long strips across the coastlines of Essex and north Kent, in Romney Marsh and the Weald, in isolated patches of the Vale of London and in Chiltern Hills, in parts of Somerset and Wiltshire, and in a few other places. The distribution of sandy soils was less pronounced: they can be found in parts of East Anglia and of the Thames basin, in the High Weald, and along the coastlines of Dorset and Hampshire. In contrast to these two soil types, deposits of loams are clearly predominant throughout this region and especially in the Northdown Country, in much of the plains along the southern coastline, and in a long, mainly uninterrupted, strip ranging from the coastline of Dorset all the way to the northeastern coastline of Norfolk. The different soil structures had a profound impact on the form and efficiency of practiced husbandry systems. Clay soils, especially when they happen to be poor in organic matter, tend to retain excessive quantities of water, which, in turn, prevents aeration and therefore renders plant growth very problematic. Sandy soils present precisely the opposite problem, that is, they fail to retain enough water and organic matter and, by implication, plants' roots starve for lack of useful nutrients. In contrast, the medium composition of loamy soils—that is, the presence of approximately equal quantities of clay, silt, and sand—renders them highly fertile,[15] especially when they contain also chalk and limestone, as was the case in large parts of the southern-eastern counties.

Chalk and limestone soils are easy to work, drain efficiently, and, most important, reduce acidity by producing a neutral salt called calcium nitrate. The reduction of acidity accelerates the decomposition of organic matter, thereby increasing yields in the short run, but this rapid use of nutrients imposes, at the same time, the need for constant replenishment of manure in order to sustain high yields in the long run. The answer could have been found only in a form of tillage that solved the problem of manuring by respecting the integrity of animal husbandry; the only system that could achieve such results was convertible husbandry.[16] In theory, the traditional two- and three-course rotations

---

Campbell, James Galloway, Derek Keene, and Margaret Murphy, *A Medieval Capital and its Grain Supply: Agrarian Production and Distribution in the London Region c. 1300* (Belfast and London, 1993), 117, especially figure 11; P. F. Brandon, "Farming Techniques: South-eastern England," in *The Agrarian History of England and Wales* 2, *1042–1350*, ed. H. E. Hallam (Cambridge, 1988), 314; H. E. Hallam, "Farming Techniques: Southern England," in *Agrarian History* 2, ed. Hallam, 352.

[15] Clay and sandy soils can also achieve a certain degree of fertility assuming their organic content is high; see Louis M. Thompson, *Soils and Soil Fertility* (New York, 1978), 4, 11, 48–49, 100–01, 183–84.

[16] For the stylized features of convertible husbandry, see Eric Kerridge, *The Agricultural Revolution* (New York, 1968), 39, 181, 195, 202. Kerridge exaggerates the merits of

practiced in the context of a permanent division between arable and pasture can also retain the necessary balance, but in practice, and especially during periods of population growth, there was always a tendency to move the boundaries of grains at the expense of grass.

In contrast, convertible husbandry succeeded because it developed an important innovation: the pastureland was ploughed periodically to prevent the grass from becoming water-logged and to mix well the manure with the soil in order to increase its effectiveness when the land was turned to cultivation. The greater availability of grass meant more animals per given acreage, enabling the farmer to sustain larger herds and flocks and, by implication, yielded more meat, hides, and milk.

More efficient grazing did not come at the expense of arable crops. Grass constantly deposits organic matter into the soil and restricts the supply of air to microorganisms, with overall beneficial effects for the soil's fertility. Converting established pastures to temporary tillage was the first step toward directing the stored fertility into plants. In the subsequent cropping cycles the same level of fertility was sustained, and even increased, by the constant droppings of manure and urine in the temporary grasslands that were ploughed under; when the change to arable came a few years later, the soil was so rich in nutrients that there was no need to fallow. The cumulative effects of these changes were bound to improve the soil structure dramatically by making it "crumbly" and "loamy"; once formed after a few alternation cycles, the quality of this structure could be preserved even if the number of years for which it was under temporary pasture was slightly reduced. The first observer to have made a comprehensive reference to convertible husbandry was Blith, who expressed the belief that when land is converted from common fields to the new system and tillage is reduced by one third, total output could still fluctuate around the same levels.[17] Such claims are certainly exaggerations but, at the very least, convertible husbandry offered greater flexibility. This system could be adopted in fertile soils, such as those of eastern Norfolk, and geared toward a high level of intensity—that is, by dedicating a large portion of the land to temporary tillage—or it could be adopted in the poor soils of the East Anglian Breckland and of the Weald, but in such areas it would have been imperative to reduce the size of the tilled portion.

Historically, there was also a close correlation between chalk/lime-

convertible husbandry, as I argue in a forthcoming paper, tentatively entitled "Convertible Husbandry vs. Common-Fields: a Model on the Relative Efficiency of Medieval Field Systems." Nevertheless, under the right circumstances, this system could generate a somewhat larger product and revenue base than common fields.

[17] Cited in Kerridge, *Agricultural Revolution*, 207–08.

stone soils and the cultivation of legumes, especially vetches.[18] The beneficial effects of legumes lie in reducing acidity by adding nitrogen to the soil and acting as an obstacle to weed growth when planted between successive grain crops. Of course, the appropriateness of the soil is a necessary but not sufficient condition for their cultivation in the south-east; in fact, this region needed legumes the least since chalks and limestones make acidity less of a problem. The answer to this apparent paradox relates to their nitrogen-adding capacity, which was extremely useful in the context of an intensive convertible husbandry that greatly reduces the size of the fallow, and, most important, in that legumes were rich in proteins, making them ideal fodder for horses, particularly in areas that lacked extensive meadows.

Horses were particularly suitable for ploughing and other tasks on light and sandy soils or in thin chalklands, because such soils are easily workable, making them ideal for the delicate horse. Edaphic conditions were probably the salient criterion in choosing either horse or ox because other considerations failed to point to either animal as a clear-cut winner.[19] Horses had a superior pulling capacity, pulling the same weight 50 percent faster, thus making them the obvious choice for transportation, hauling, and harrowing; in addition to improving labor productivity, they also had greater durability, allowing them to work one or two extra hours a day. On the other hand, oxen had a slower depreciation cost, a lower maintenance cost (7.2s., as opposed to 10.2s. per horse), were edible in old age, and were cheaper to purchase. The enumeration of all these variables made the final decision such a complicated matter that we would probably not go wrong by assuming that edaphic conditions weighed heavily. When such conditions were favorable, as with the light loams of East Anglia that allowed two-horse plough teams, savings could be spectacular: calculations show that a horse at Ormesby St. Margaret (Norfolk) could plough twice as many acres per year as a horse working on the clay soil of Eastwood (Essex); the difference is bound to be equally spectacular when the comparison is made with ox-teams working clay lands.[20]

Ploughs were another important contributor to the growth of labor productivity. The physical properties of the soil—its strength and resis-

[18] B.M.S. Campbell, "The Diffusion of Vetches," *Economic History Review* 41.2 (1988):196, 198, 202–05.

[19] Slicher van Bath, "The Influence of Economic Conditions on the Development of Agricultural Tools and Machines," in *Mechanization in Agriculture*, ed. J. L. Meij (Chicago, 1960), 5; John Langdon, *Horses, Oxen and Technological Innovation: the Use of Draught Animals in English Farming from 1066 to 1500* (London, 1986), 158–59.

[20] R. H. Britnell, "Farming Practice and Techniques: Eastern England," in *Agrarian History* 3, ed. Miller, 206.

tance—were the main determinants of their variability, but the personal caprice of the local artisan also added an element of randomness.[21] When the soil is light and relatively dry, as in the sandy soils of East Anglia, turning the furrow becomes quite easy and consequently makes the use of a light and small plough feasible. The answer was found in the one-wheeled plough, whose speed and swiftness, along with its ability to be drawn with just one or two horses, provided a significant potential for increased productivity at low cost—certainly appreciated in a region requiring repeated ploughings in order to deal with the excessive problem of weeds. Other types of soil demanded different responses. The gravel soils of Hertfordshire favored the use of a heavier, steadier, more balanced instrument, and the solution was given by the two-wheeled plough. On the other hand, wheels were a great impediment when facing moist, sticky, and clay soils, as in parts of Buckinghamshire and in the middle Thames valley, where the foot-plough was quite popular; the removable piece of wood or iron inverted in the plough-beam provided the necessary balance and kept the ploughshare at a more or less steady angle. Finally, in some hilly and stiff soils of East Anglia and the East Midlands, preferences were attached to the swing-plough whose absence of a "foot" or wheel spared the driver from bumpy rides.

The ecological profile of the northern and western counties was strikingly distinct from that prevailing in the southern-eastern portion of the country. The weather was far more wet and cold, the morphology of the terrain was more rugged given the higher density of mountain ranges and moorlands, and, most important, the distribution of "good" versus "bad" soils was not particularly favorable.[22] It is not that the northern and western counties lacked fertile loams. Such soils are found in parts of Cheshire, in the coastal plains of Lancashire, Yorkshire, Cornwall, and Devon, as well as in isolated patches in the West Midlands, for instance, in the Vale of Evesham and in Oxford Heights; the remarkable yields of Cuxham clearly had a lot to do with

---

[21] Joan Thirsk, "Farming Techniques," in *The Agrarian History of England and Wales* 4, *1500–1640*, ed. Thirsk (London, 1967), 163–65.

[22] Kerridge, *Farmers of Old England*, 79–97; Finberg, *Tavistock Abbey*, 85–88; John Hatcher, *Rural Economy and Society in the Duchy of Cornwall, 1300–1500* (Cambridge, 1970), 9–10; Ian Kershaw, *Bolton Priory: the Economy of a Northern Monastery, 1286–1325* (London, 1973), 40; G. Elliott, "Field Systems of Northwest England," in *Studies of Field Systems in the British Isles*, ed. Alan Baker and Robin Butlin (London, 1973), 75; Thirsk, "The Farming Regions of England," 29, 41, 53, 64, 80–81, and "Enclosing and Engrossing," 212, both in *Agrarian History* 4, ed. Thirsk; R. H. Hilton, *A Medieval Society: the West Midlands at the End of the Thirteenth Century* (Cambridge, 1966), 14–15; H.S.A. Fox, "The Occupation of the Land: Devon and Cornwall," in *Agrarian History* 3, ed. Miller, 156–57, 160–61.

the soil of the township. Instead, the problem lay in the predominance of heavy and thick clays, soils that were often acidic, making cultivation difficult even today; in the Middle Ages it was nearly impossible. Typical of these conditions were the large expanses in Cheshire and Lancashire, the Lake District and the Pennines, much of the West Riding, especially in the vicinity of Halifax, in north- and mid-Devon and most of Cornwall and, finally, throughout the West Midlands, for instance, in the woodland zones of central Worcestershire and Warwickshire; some of these lands at the fringes of moors were taken under cultivation during the demographic growth of the pre-plague decades, but they were quickly abandoned in the later Middle Ages. The thickness of the clays, coupled with the high moisture levels, due to the continuous and intense precipitation, created serious problems with achieving adequate drainage. The result was that they "would be so frequently water-logged in the winter as to break the heart, as well as the implements, of the ploughman. They would also be difficult to turn into fine enough tilth in the spring and thus waste much of the seed." This type of land was "most likely to suffer from insufficient manuring . . . presumably predominated among the lands abandoned by the plough."[23]

As with the south-east, the type of soil prevailing in the northern and western territories acted as a magnet underneath a sheet that determines the movement of iron filaments; in our case it defines the bias toward certain technologies. Manure is obviously not a concern in a largely pastoral economy, but its value is greatly diminished when high levels of soil acidity are present. The existence of nitric acid produced by various microorganisms can be neutralized only by the presence of calcium nitrate, which is the by-product of marl or lime.[24] Calcium nitrate contributes to the fertilization of the soil by neutralizing its acidity and thus allowing manure to be effective; in addition, when it comes specifically to heavy and acid soils, marl and lime allow more air and water to penetrate and also help to eliminate certain weeds that thrive on those terrains. It has to be emphasized, though, that considerations relating to affordability and the physical availability of these substances rendered their usage cumbersome. Also, the strong winds and heavy rainfall, which are constant features of the landscape in the north and west, tend to quickly dissolve the lumps of lime and marl, thus necessitating their constant replacement.

[23] Postan, "England," 558–59.

[24] M. A. Havinden, "Lime as a Means of Agricultural Improvement: the Devon Example," in C. W. Chalklin and M. A. Havinden, *Rural Change and Urban Growth, 1500–1800* (London, 1974), 104, 109, 112–13.

Wherever marl or lime is not available, or is considered too costly, practical ingenuity could also have led to alternatives.[25] In coastal areas, from Cornwall to the West Country and Cumberland, seasand and seaweed (called "tangle") were other means of treating the soil. Seaweed was thought to be very good for barley yields when ploughed in a green or rotten state, but its effectiveness would not last for more than a year. An alternative technique known since the pre-plague period in the southwest was beat-burning: the grass was cut, dried by the sun and wind, burned, and the ashes were spread on the soil before ploughing. If not overdone—it destroys the humus of the soil—it neutralizes acidity and adds nitrogen to the plants' food.

Besides the application of conditioners, the challenge was to balance the two uses of land without excessive ploughing and continuous cropping of the heavy clays, even though one of the best ways to fight the perennial problem of weeding was constant and regular ploughing. The solution was—and here we come to another correlation between heavy clays and the issue of their technical bias—the introduction of convertible husbandry. We recall that the flexibility of the system allowed a low-intensity cultivation of a given acreage (sometimes as low as one-fifth or one-fourth of the total), thus radically reducing the amount of ploughing and cropping. In fact, this organizational system was perfectly suited to the north and west because its bias toward animal husbandry accommodated the pastoral character of this region. Specifically, the amount of hay and grass it generated was far superior to the mossy cover and coarse weeds and herbs that could have grown in clay soils if land were used as a rough pasture; the latter could not keep up with the constant needs of grazing and was bound to be overrun after ten to fifteen years.

In terms of draft animals, edaphic conditions in this region favored, by and large, the use of oxen[26] for reasons that are easily guessed: the high precipitation of the north and west and the poor capacity of heavy clays to drain themselves naturally made the bulky ox the ideal power source in muddy and slow-moving terrains; this tendency is strengthened because pastoral regions have, by definition, extensive pastures and meadows, and thus larger quantities of hay and grass. These two features are sufficient to sustain oxen, whereas horses also eat legumes or inferior grains. Finally, ploughs were specially designed to conform to the unique demands of the stiff and heavy clays.[27] The

[25] Kerridge, *Agricultural Revolution*, 170, 173, 240; Hatcher, *Rural Economy*, 12–13; Finberg, *Tavistock Abbey*, 89–94, 107–08.

[26] Langdon, *Horses, Oxen and Technological Innovation*, 66.

[27] Ibid., 128–29, 134, 138, 204–05, especially figures 30, 34, and table 29.

TABLE 3. Ideal "technological matrices" based on regional variations of ecological factors

	Draft animals	Plough types	Fertilizers/conditioners	Course-rotation
South east	Mainly horses	Wheeled-, foot-, swing-	Manure, legumes	Convertible husbandry
North west	Mainly oxen	foot-	Manure, legumes, marl, lime, seasand, seaweed, beat-burning	Convertible husbandry

necessary modifications were directed toward increasing the weight of the plough and substituting the wooden or iron "foot" for wheels, which solved the problem of bogging down in sticky and muddy soil.

Table 3 summarizes what ought to have been the ideal "technological matrices" of each region based on their unique ecological profiles. The items enumerated in this list of preferred inputs does not exhaust the range of medieval technologies; in fact, it omits important resources such as implements and seeding-rates.[28] In terms of such technologies, though, ecological factors did not define significant regional variations; for instance, there were small substantial differences across regions in the construction and design of implements such as flails, harrows, sickles, scythes, or spades.

In closing this section, it is useful to refocus our line of reasoning by reiterating what has been stated at the beginning: ecological factors raise very particular demands when it comes to the use of agrarian technologies. Therefore, the lack of a uniform technological diffusion is not an index of deficiency. *Each region ought to be judged on the basis of how close it came to realizing its productive potential defined by its natural conditions, and not on the basis of whether it was less productive, in absolute terms, than another region with a more favorable physical endowment.*

* * *

The questions that remain to be addressed are to what extent the qualitative and quantitative diffusion of technologies in our two broadly identified regions deviated from what we defined as their ideal matrices and, in the second place, what factors account for the phenomenon; the first question will be dealt with in the present section, the second in the following two sections. Starting with the first part of

[28] The case of water- and wind-mills will not be considered because I chose to classify them as industrial technologies, perhaps to the objection of some historians.

the issue and the southern-eastern segment of the country during the pre-plague period, we can establish the sporadic adoption of convertible husbandry in a cluster of townships located in East Anglia, Buckinghamshire, Kent, and Sussex.[29] One of the major characteristics of these areas, and probably a critical precondition regarding the adoption of convertible husbandry, was the weakness of communal regulations and seigneurial controls. Both demesnial fields and peasant holdings tended to be compact and either permanently or temporarily enclosed. Crop rotations were determined on an individual basis, although in some instances a system of shifts superimposed upon the multiple fields established a sense of order and regularity; such shifts led to a three-course rotation or even to one of a higher order.

In the fertile soils of this area a quite intensive version of convertible husbandry was practiced. For instance, in three manors of coastal Sussex, the size of the fallow varied between 7 and 20 percent. Typical examples of how the system worked are the Bury St. Edmunds manors of Hinderclay and Worlingworth, both in Suffolk. The land at Worlingworth was divided into twelve fields of very unequal sizes, out of which nine or ten were under crop each year, whereas the rest were used as foldcourses. The frequency of fallowing in each field seemed to correlate with the crop that was grown in it, the ones growing mostly legumes being the ones fallowed the least. Of course, in parts of the southeastern corner where edaphic conditions were less favorable, as in the Breckland and the Weald, such intensive practices could have proved disastrous. In such cases the infield-outfield variation was geared toward a lower level of intensity. The infield was intensively cultivated and periodic encroachments into the outfield were often made.

Alas, the merits of convertible husbandry were either unknown or not appreciated in the central-south and the East Midlands, where the permanent division between arable and pasture along with the monotonous periodicity imposed by the two- and three-course rotations were bound to take their toll on the soil's fertility.[30] The practice of a two-course rotation outnumbered the three-course rotation in a ratio of

[29] For the diffusion of convertible husbandry and the way it was practiced in various localities, see Eleanor Searle, *Lordship and Community: Battle Abbey and its Banlieu, 1066–1538* (Toronto, 1974), 274; D. Roden, "Field Systems of the Chiltern Hills and their Environs," in *Studies of Field Systems*, ed. Baker and Butlin, 336; Baker, "Field Systems of Southeast England," 429; H. E. Hallam, "Farming Techniques: Eastern England," in *Agrarian History* 2, ed. Hallam, 274–75, 279–81, 299–300; Brandon, "Farming Techniques: South-eastern England," 314–15, 318–25.

[30] Hallam, "Farming Techniques: Southern England," 344; Hallam, "Rural England and Wales, 1042–1350," in *Agrarian History* 2, ed. Hallam, 1002; D. L. Farmer, "Grain Yields on Westminster Abbey Manors, 1271–1410," *Canadian Journal of History* 18.3 (1983):345–46.

two to one in central-southern England, and it was particularly dominant in the poor soils of Dorset, Somerset, and Wiltshire. Nevertheless, the three-course rotation was clearly on the rise as the Neo-Malthusian scenario unfolded, both in the central-south and the East Midlands. The officials of the Winchester bishopric, though, did not follow the overall trend and, according to Farmer's estimates for the period 1271–99, some manors using the two-course rotation could have ended up with significant monetary gains if the decision had been made to shift to a higher-order rotation, because soil exhaustion was still at its initial stage.

The conservatism of the Winchester manors, and of the majority of southern-eastern estates that adopted a rigid open-field system, had negative repercussions for the management of their animal stock and the availability of manure.[31] The problem was not that the number of herds and flocks could not be increased. The bishopric of Winchester, for instance, expanded the size of its arable land and its access to downland pastures during the first part of the thirteenth century and, by implication, was able to accommodate a larger animal population whose peak, in terms of absolute numbers, was reached by 1260. Its livestock ratio, devised by Postan and Titow, was about 61 units per 100 acres at that time. The absolute number of animals did not increase in the following decades, so the animal ratio stayed the same, but as its demesnes began to contract, particularly during the early part of the fourteenth century, the number of animals per acre increased and, by definition, so did the animal ratio, which went up to 75 units per 100 acres. Peterborough Abbey also did quite well given its emphasis on pastoral farming. Despite the faster expansion of its farming area compared with its animal population between the early twelfth and early fourteenth centuries, leading to a small decline of its animal ratio, the latter remained at figures comparable to those of the Winchester manors. Other southern estates, such as Westminster Abbey, did significantly worse in this respect.

But how should we go about interpreting this evidence? Other things being equal, a high animal ratio translates to more manure and higher grain yields; that is precisely what has been documented for those Winchester manors with animal ratios above the average for the estates as a whole, whereas manors with ratios below the average witnessed declining yields over time. But a large animal population that is

[31] J. A. Raftis, "Farming Techniques: the East Midlands," in *Agrarian History* 2, ed. Hallam, 338–39; Hallam, "Farming Techniques: Southern England," 346; Titow, *Winchester Yields*, 30–31; Kathleen Biddick, *The Other Economy: Pastoral Husbandry on a Medieval Estate* (Berkeley, 1989), 62–64, especially table 12.

not fully integrated with arable farming can have but a limited effect on yields, and that is precisely the type of problem generated when arable and pasture are assigned permanent roles. A large portion of manure is wasted by being deposited in pasturelands, even more so since it is not ploughed under; hence the "chronic state of undermanuring" documented in the Winchester manors.[32] A partial remedy for the problem would have been the systematic treatment of fields with barnyard manure, but evidence regarding this activity is "scattered and vague" when it comes to southern demesnes.[33] Barnyard dung, carried and spread through customary services, was extremely scarce and, at best, sufficient to treat just a few acres a year. The problem was unique neither to the Winchester estates nor to the thirteenth century. At Hormead (Hertfordshire) in 1326–27, only 10 acres (out of 150) were treated either by carting or by folding, a situation little changed by 1344–45. At Westmill only 10 percent of the 500 demesnial acres were treated by manure.

Fluctuating, and often low, levels of animal stock could also have been found in counties that adopted convertible husbandry, since the two are not necessarily deterministically related.[34] The cattle herd at Hinderclay was quite substantial until 1293 (at a time of high wheat yields), but it diminished thereafter, and so did wheat yields, whereas at Worlingworth the herds of cattle and sheep increased dramatically but quite late, namely during the second quarter of the fourteenth century; by implication, in those manors, and others (e.g., Elmswell, Woolpit), the acreage treated by dung was often quite limited. But these are mostly exceptional cases, since Suffolk, including its heathland areas, sustained a large number of sheep whose manure was supplemented by farmyard supplies; the treatment of 110 demesnial acres (out of 477) at Redgrave (1250) is more representative of the county's practices. Similar evidence comes from much of Sussex, as at Bosham manor, where 28 percent of the demesne was treated by carted dung and a further acreage by folding sheep. Norfolk was equally impressive in this respect. The cultivation of legumes in some Norfolk demesnes led to a reduction of both permanent and temporary pastures but, instead of suppressing the amount of livestock, it expanded it by

---

[32] Titow, *Winchester Yields*, 30.

[33] Hallam, "Farming Techniques: Southern England," 346.

[34] Hallam, "Farming Techniques: Eastern England," 285–87, 301–02; Brandon, "Farming Techniques: South-eastern England," 322–25; Mark Bailey, *A Marginal Economy? East Anglian Breckland in the Later Middle Ages* (Cambridge, 1989), 91; B.M.S. Campbell, "Agricultural Progress in Medieval England: some Evidence from Eastern Norfolk," *Economic History Review* 36.1 (1983):32–33, 35–36; M. Mate, "Medieval Agrarian Practices: the Determining Factors?" *Agricultural History Review* 33.1 (1985):24.

encouraging stall-feeding and the supply of farmyard manure, which was supplemented in some cases by the purchase of nightsoil from Norwich.

Of course, ample manuring was a necessary but not sufficient condition for the sustenance of high yields.[35] Manure, if left exposed on the soil, loses its value, making imperative the preparation of the fallow with frequent ploughings; three or more ploughings per season, using the turn-wrest or swing ploughs, was a practice that has been documented for the coastal southeastern counties but not much elsewhere.[36] Manorial officials in those counties played also a pioneering role when it came to the use of marl.[37] The existing evidence points to the East Anglian manors of Bury St. Edmunds, where up to a quarter of demesnial land was treated at a given year, in many eastern Norfolk manors (beginning with Martham in 1263–64), in some Essex manors of Canterbury Cathedral Priory and of St. Paul's Cathedral, and it was also quite extensive in Kent and Sussex, where it was supplemented with slush and mud. Marling was also undertaken selectively in the otherwise less progressive southern estates of Glastonbury Abbey and in the bishopric of Winchester, although the evidence for the latter thins out over the course of the thirteenth century. In most cases marling was directed toward the treatment of less fertile soils.

Soil acidity was also fought with the aid of legumes,[38] whose appearance was particularly dense in places like Bosham, Westerham, and northeastern Kent that adopted intensive practices in the context of convertible husbandry. Legumes made great strides in many Norfolk

---

[35] At Sevenhampton manor, for example, yields declined by a fifth between the periods 1269–79 and 1280–87 despite the slight increase of the animal population. Horses, oxen, and the dairy herd were slightly less numerous, but the number of swine and especially the increase in the number of sheep more than compensated for it, given, at the same time, the slight contraction in the size of the cultivated acreage. See Hallam, "Farming Techniques: Southern England," 361.

[36] W. O. Ault, *Open-field Farming in Medieval England: a Study of Village By-laws* (London, 1972), 17; Brandon, "Farming Techniques: South-eastern England," 322.

[37] Hallam, "Farming Techniques: Eastern England," 285–87; Brandon, "Farming Techniques: South-eastern England," 314, 322–23; Hallam, "Farming Techniques: Southern England," 347–48; P. F. Brandon, "Demesne Arable Farming in Coastal Sussex During the Late Middle Ages," *Agricultural History Review* 19.2 (1971):123, 129–30; Campbell, "Agricultural Progress," 34; Bailey, *A Marginal Economy?* 88–91; Titow, *Winchester Yields*, 31.

[38] Hallam, "Farming Techniques: Eastern England," 294–96, 298; Brandon, "Farming Techniques: South-eastern England," 318–20; Raftis, "Farming Techniques: the East Midlands," 332; M. Mate, "The Agrarian Economy of Southeast England Before the Black Death: Depressed or Buoyant?" in *Before the Black Death: Studies in the 'Crisis' of the Early Fourteenth Century*, ed. Bruce Campbell (Manchester, 1991), 81–82; Campbell, "Agricultural Progress," 31; J.Z. Titow, *English Rural Society, 1200–1350* (London, 1969), 41–42; Mate, "Medieval Agrarian Practices," 28; Farmer, "Grain Yields on Westminster Abbey," 346–47.

manors like Hemsby, Wretham, Lessingham, Forncett, Wymondham, and Calthorpe, constituting approximately 14 percent of the total acreage for the period 1239–1350; in eleven manors of Abbey St. Benet that cultivated legumes above the average, yields of other crops were also above the average. Data from four Sussex manors reveal that legumes, especially vetches, occupied between 13 and 38 percent of the demesnial acreage during the last quarter of the thirteenth century, a percentage that was retained, and even increased, during the fourteenth century.

In other places leguminous crops became important quite late, as in the Surrey manors of Merton College, in the estates of Christ Church, where they covered 18 percent of the total acreage in 1322, and in some manors in the Weald. Elsewhere they failed to acquire a strong foothold in the pre-plague period: the estates of the Winchester bishopric dedicated 0.97 percent of their acreage to legumes at the beginning of the thirteenth century and 8.26 percent by 1345. The Winchester data, as well as similar information from Ramsey Abbey, reflect an overall trend regarding the central-southern counties and the East Midlands with a few exceptional cases, for instance, the Nottinghamshire manor of Wheatley, whose acreage dedicated to legumes fluctuated between 11 and 30 percent in the period 1289–1319. In addition, legumes often failed to make a significant contribution to raising yields due to grave mistakes in their placement in the rotation cycle. For instance, in the case of Westminster Abbey, which planted ample quantities of legumes in some of its demesnes, yields did not seem to benefit. That is because legumes were followed by fallowing. Thus the released nitrogen ended up benefiting the weeds; instead, the right practice would be to follow with a barley crop because its roots are shallower, making the absorption of nitrogen easier.

Interestingly enough, the diffusion pattern of legumes displays a close correlation with that of horses.[39] Legumes, rich in protein, were needed particularly in regions that lacked extensive meadows to provide fodder in the late winter and early spring; they could be given unthreshed to horses. A sample of demesnial records for the period 1250–1320 shows that horses comprised 26.7 percent of working animals at a national level and that East Anglia, Kent, and Essex were at the top of the regional breakdown with 50 percent. The Home Counties (especially Bedfordshire and Hertfordshire), the East Midlands (e.g. Northamptonshire), and the counties in central-south England followed in the list in terms of their adoption rates. Besides the pres-

[39] Raftis, "Farming Techniques: the East Midlands," 336–37; Hallam, "Farming Techniques: Southern England," 359, 362; Langdon, *Horses, Oxen, and Technological Innovation*, 87, 100, 256–59; Campbell, "Agricultural Progress," 36–37.

ence of convertible husbandry and legumes, which favored horses, as opposed to rigid rotations and extensive meadows (e.g. East Midlands) that were associated with oxen, some other factors were relevant in the diffusion of the two animals: horses appeared in areas with strong commercial forces, in medium-size estates that utilized the more versatile horse to exploit economies of scale, and in areas with soils composed mainly of light limestone, as opposed to heavy clays where the ox was more appropriate.

In summary, there is clearly a very close correspondence between the impressive yields that were recorded in manorial estates along the southeastern coast and the technological choices they made (the former being a reflection of the latter), as opposed to the majority of estates in the rest of this region, where there was a wide divergence between the technical choices deemed ideal by ecological factors and those actually adopted. This distinction is apparent in the diffusion patterns of technologies that could elevate the productivity of land, such as convertible husbandry, manure, legumes, and seeding-rates,[40] and of technologies that could have contributed to increased productivity of labor, such as horses.

In the end, there is clearly a spectrum of efficiency standards in this region. At the lower bottom of the scale, we discern a pattern of conservatism, exemplified by the bishopric of Winchester, that led eventually to stagnation and decline. Its officials retained a rigid division between arable and pasture and an inflexible system of rotations, both choices leading to low levels of manuring; in addition, they failed to engage in a systematic and long-lasting effort toward marling and introducing legumes. As a result, yields remained at mediocre levels throughout the pre-plague period. At the polar opposite of the scale we encounter signs of progressiveness and impressive growth, evident in many southeastern manors, especially in Norfolk. The adoption of convertible husbandry, the efficient management of manure supplies, and the systematic cultivation of legumes resulted in high levels of productivity; in fact, the yields per seed cited in the Appendix from this area tend to underestimate progressiveness because they obscure the limited extent of fallowing.[41] Therefore, in terms of total output, the efficiency gap between eastern Norfolk and Winchester manors is far

---

[40] The density of seeding rates was much higher in places like Canterbury Cathedral Priory and Battle Abbey, as opposed to the inland estates of this region; thicker sowing was an effective way of counteracting weed growth and dealing with the problem of seed loss inherent in the broadcast method. See Brandon, "Farming Techniques: South-eastern England," 320–22.

[41] The significance of this point is clarified by Campbell, though in a comparison between the manors of Martham and Cuxham; see his "Arable Productivity in Medieval England: Some Evidence from Norfolk," *Journal of Economic History* 43.2 (1983): 390–92.

wider than is indicated by the respective values of the Appendix. There is also an intermediate layer, consisting of estates such as Bury St. Edmunds and Christ Church, whose technological standards were quite advanced but often varied from manor to manor or from period to period; we noted, for instance, a relative decline in the number of animals and the level of manuring undertaken in the manors of Hinderclay and Redgrave during the first part of the fourteenth century, developments that coincided with a decline of yields. The latter oscillated at, or somewhat above, those achieved in the Winchester manors, although the difference was wider in terms of total output given the greater intensity of cultivation practiced by Bury St. Edmunds and Christ Church.

The northern and western parts of the country exhibited a closer technological conformity to the ideal standards imposed by the constraints of environmental factors, especially when it comes to the organizational schemes they adopted regarding the use of arable and pasture.[42] The field systems of Devon and Cornwall, for instance, largely resembled the arrangements prevailing along the southeastern coast, that is, land tended to be in compact holdings, often enclosed, where a form of convertible husbandry was practiced, as in the Duchy of Cornwall and in Tavistock Abbey. Part of the land would be continuously cultivated for a number of years—the duration depending on the fertility of the soil—and the rest would make up the leys that were used for pasture; after a few years part of the arable would interchange roles with the leys. In contrast, open fields with communal rotations and pastures were rather exceptional in the southwestern peninsula. The northern counties followed an infield-outfield type of shifting cultivation that implied continuous cultivation of the infield, with periodic resting, after its intensive manuring between harvest and spring sowing. Variations of such practices have been documented for parts of Lancashire, Cumberland, Northumberland, Yorkshire (e.g. Bolton Priory), in the forest of Pickering, and elsewhere. Even in places where a two- or three-course rotation was followed, as in parts of Durham, fields were so irregular that flexible changes were often feasible.

The typical open-field system, with its characteristic interspersion of holdings and communal rotations, was by far the dominant form of organization in the West Midlands.[43] The less intensive two-field divi-

---

[42] John Hatcher, "Farming Techniques: South-western England," in *Agrarian History* 2, ed. Hallam, 383–87; Edward Miller, "Farming Techniques: Northern England," in *Agrarian History* 2, ed. Hallam, 402–03; J. L. Bolton, *The Medieval English Economy, 1150–1500* (London, 1980), 244–45; Kershaw, *Bolton Priory*, 66.

[43] Christopher Dyer, "Farming Techniques: the West Midlands," in *Agrarian History* 2, ed. Hallam, 369, 373–74.

sion, with an often identical number of rotations, was much more common and was largely concentrated in Gloucestershire, Oxfordshire, and the southern parts of Worcestershire and Warwickshire. Its more intensive cousin was practiced in isolated pockets around the towns of Gloucestershire and Oxford (e.g. Cuxham), in the valleys of Severn and upper Avon, and in the northern edge of the West Midlands (e.g. Stratfordshire, Derbyshire). There are signs, though, of some limited flexibility evident in the occasional process of "inhoking" (i.e. tilling) part of the fallow, and in the variations of the proportion of land dedicated to winter- and spring-sown crops in two-field townships.

The adoption of flexible husbandry systems and the pastoral specialization of this region led to animal stock levels that seem to have been higher than in the rest of the country.[44] The animal population and the extent of manuring were very impressive in the southwestern peninsula, as indicated by the evidence from the Duchy of Cornwall and other estates. Sheep flocks and cattle herds were also very extensive and were sources of great revenue in the north, as in the case of Bolton Priory, which specialized in the marketing of fleeces. West Midland landlords were equally conscious of the value of manuring, evident in Oldington manor (Worcs.), whose demesne was treated systematically during the 1280s (about 20 percent every year), and in Temple Guiting (Glos.) where the respective proportion was up to a third in 1326–28. The use of soil conditioners[45] is also well documented beginning with references to liming and marling in Cheshire, Lancashire, and Yorkshire, some of which date back to the twelfth century and continue with quite a few West Midland landlords. In addition, the student of the period is struck by the multiplicity of responses to the challenges posed by the poor edaphic conditions: beat-burning and the application of sand were well-regarded practices in Devon and Cornwall (e.g., Tavistock Abbey, earls of Devon) whereas in the coastal villages of Yorkshire, Northumberland, and Cumberland we find some of the earliest references to the use of seaweed, along with marl and sand.

One element of the "technological matrix" that was deemed ideal for the north and west but failed to gain a strong foothold was the cultivation of legumes.[46] In the northern counties they seemed to have been popular in some manors in the East Riding of Yorkshire, but vir-

---

[44] Ibid., 378; Miller, "Farming Techniques: Northern England," 409–11; Hatcher, *Rural Economy*, 14–16; Hatcher, "Farming Techniques: South-western England," 395–97.

[45] Dyer, "Farming Techniques: the West Midlands," 378; Hatcher, "Farming Techniques: South-western England," 388; Miller, "Farming Techniques: Northern England," 404; Elliott, "Field Systems of Northwest England," 60.

tually unknown elsewhere. Very small quantities were also grown in Devon and Cornwall; from a sample of nineteen manors covering the period from 1286 to 1337, nearly half did not grow them at all, whereas in the rest the percentage of the demesne dedicated to them was usually in the single digits. The picture was not much different in the West Midlands, given a sample of seventy-nine manors: on ten of them legumes covered a quarter of the demesne (Cuxham among them); on fifty-four it was less than 10 percent, and fifteen manors did not grow them at all.

The lack of legumes in this region, though, should not necessarily be judged as an index of backwardness, since one of their main functions (i.e. providing fodder for horses) was not needed due to the wide prevalence of oxen fed in the abundant rough pastures and meadows.[47] Given the existing ecological conditions, it is not surprising that horses constituted only 12.5 percent of draft animals in West Midland demesnes by 1300. Horses were used mainly for carting and harrowing, as were the 116 horses of Bolton Priory at the end of the thirteenth century, as opposed to being components of the plough-team, which was mostly ox-drawn; one notable exception was Cuxham, whose stony soils favored mixed teams. Of course, some limited deviations from the ideal standards are to be expected. Some areas did warrant the utilization of horses but demesnes failed to adopt them: they might have been ideal, for instance, in parts of the West Midlands that have a variety of lighter soils or lack meadows and pastures (southeast Worcestershire, the Felden area of Warwickshire), or in the hilly parts of Devon and Durham, which have relatively low levels of precipitation; nevertheless, horses failed to make significant inroads in these areas. Finally, regarding the mechanical component of the plough-team, the plough itself, we also witness a quite consistent conformity to the demands of edaphic conditions that favored the use of unwheeled ploughs, especially of the swing variety; foot-ploughs followed in the preferences of manorial officials, but they were particularly popular in the West Midlands.[48]

The preceding evidence presents a picture that cries out for revising the long-held view that pastoral regions are, by definition, backward. On the contrary, flexible field systems and rotations were more prevalent in this region, and supported an animal population that seems to have been higher, than in the south-east. Ample quantities of manure

[46] Dyer, "Farming Techniques: the West Midlands," 379; Hatcher, "Farming Techniques: South-western England," 391; Miller, "Farming Techniques: Northern England," 406.

[47] Dyer, "Farming Techniques: the West Midlands," 380; Kershaw, *Bolton Priory*, 94–95; Langdon, *Horses, Oxen and Technological Innovation*, 256–57.

[48] Langdon, *Horses, Oxen, and Technological Innovation*, 134, 136, 138, 245–46.

were supplemented by a number of conditioners whose quantitative extent is difficult to reconstruct but whose range is beyond dispute. It is these achievements, along with the appropriate use of oxen, that elevated the northern and western counties to the high level of efficiency that is often evident in the recorded crop yields.

* * *

The factor that weighs most heavily in explaining these different patterns of technological diffusion and the wide spectrum of crop yields is the regional variations in the appropriation mechanisms that characterized the relationship between a manorial network and its tenants. There was a wide variety of such mechanisms across the country, but the most effective of them were found in areas of mixed husbandry, with a high frequency of anciently-established ecclesiastical estates. One or both of these conditions were met almost everywhere across the southern-eastern region and it is only in parts of a coastal arc stretching from East Anglia down to Sussex that the seigneurial authority failed occasionally to reach its full force. These two conditions could also have been found across the northern-western region, but what was the norm elsewhere became the exception here; in other words, the quantitative distribution of powerful estates across the country was such as to justify the distinction into two regional patterns based on the degree of seigneurial power.

The difference was not so much in terms of the level of money rents[49] and the range of other obligations payable in money or in kind. Money rents in the south-east, when determined on the basis of custom and tradition, defined a center of gravity in the range of 4d.–6d. an acre (based on the wealth subsidies of 1334), although they could reach down to 1d., as in the case of the Kentish *gafol.* The same range is revealed in the West Midlands, where some free tenants paid as low as 1/2d. an acre, whereas their customary counterparts paid up to 6d. Rents in northern counties were not strikingly different, judging from a

[49] For the range of money rents across the country, see Campbell et al., *A Medieval Capital*, 139–41; Ada Elizabeth Levett*, Studies in Manorial History* (Oxford, 1938), 199; R. Hilton, *The Economic Development of some Leicestershire Estates in the Fourteenth and Fifteenth Centuries* (London, 1947), 122; Howard Levi Gray, *English Field Systems* (Cambridge, Mass., 1915), 301; Edward Miller and John Hatcher, *Medieval England-Rural Society and Economic Change, 1086–1348* (London, 1978), 45–46; R.A.L. Smith, *Canterbury Cathedral Priory* (Cambridge, 1943), 117; David C. Douglass, *The Social Structure of Medieval East Anglia* (Oxford, 1927), 69; Hilton, *The English Peasantry*, 146–47, 230; R. Hilton, *Class Conflict and the Crisis of Feudalism* (London, 1985), 106; Hatcher, *Rural Economy*, 52–54, 59, 225–26; Christopher Dyer, "Social Structure: the West Midlands," in *Agrarian History* 2, ed. Hallam, 666; Miller, "Farming Techniques: Northern England," 403.

sample of 240 manors that shows the typical valuation to be about 9d. an acre. Of course, in the case of leaseholds, which were common in both regions, but especially in the south-east, the upper limit could reach as high as 1s. an acre and occasionally much higher, reflecting the scarcity value of favorable edaphic conditions and flexible field systems.

Tenants had to bear a number of other obligations whose diverse origins, nature, and magnitude render synthetic generalizations somewhat difficult.[50] But we can point out that Kentish tenants and their counterparts in Devon and Cornwall were not burdened with many payments that were common elsewhere (e.g., merchet and chevage in the case of Kent), whereas the level of those that they did have to pay (e.g. relief) was not particularly onerous. Holders of an East Anglian *tenementum*, and the majority of tenants in places like Hertfordshire, Yorkshire, and the West Midlands, constituted an intermediate layer in the sense that their burden was heavier—having to pay tallage, heriots, merchet, and various food-rents—although the absolute amount of such payments was not exorbitant. Finally, in a far worse position were the customary tenants of Ramsey Abbey, of the bishoprics of Winchester, Stafford, Coventry, and Lichfield, and those holding land from the Lancastrian estates; it is characteristic that the collection of heriots in the Winchester manors became clearly oppressive from the 1290s onward because they were charged not only upon the death of a tenant, but also when a land transaction was taking place and in addition to entry fines.

Unlike the two aforementioned types of seigneurial extractions, the extent of labor services was very distinct across the two regions,[51] thus

[50] Levett, *Studies*, 53, 62–65, 67–68, 198, 235; Nellie Neilson, *Economic Conditions on the Manors of Ramsey Abbey* (Philadelphia, 1899), 52–60; Edwin Dewindt, *Land and People in Holywell-cum-Needingworth* (Toronto, 1971), 74–76; Douglass, *Medieval East Anglia*, 76, 79; N.S.B. Gras, *The Economic and Social History of an English Village, Crawley, Hampshire* (Cambridge, Mass., 1930), 54; Postan, *Essays on Medieval Agriculture and General Problems of the Medieval Economy* (London, 1973), 153, 161–62; Mate, "The Agrarian Economy," 108; Hilton, *English Peasantry*, 231–33; Hilton, *Class Conflict*, 105; Hatcher, *Rural Economy*, 59–60; Finberg, *Tavistock Abbey*, 77–79, 154, 194, 216–18; D. Denman, *The Origins of Ownership* (London, 1958), 87; E. A. Kosminsky, "Services and Money Rents in the Thirteenth Century," in *Essays in Economic History* 2, ed. E. Carus-Wilson (New York, 1922), 43; G. Coulton, *The Medieval Village* (London, 1989), 76–77, 79, 82, 85; Dyer, "Social Structure: the West Midlands," 666–68.

[51] Hilton, *Leicestershire Estates*, 77–78; Levett, *Studies*, 194, 199, 203–04; Neilson, *Ramsey Abbey*, 29–49; Dewindt, *Land and People*, 68, 72–73, 75–77, 85, 93; R. Hilton, *The Decline of Serfdom in Medieval England* (London, 1969), 19–20, 22–23; Smith, *Canterbury*, 122–27; M. R. Postgate, "Field Systems of East Anglia," in *Studies*, ed. Baker and Butlin, 307; G. Davenport, *The Economic Development of a Norfolk Manor, 1086-1565* (London, 1906), 63–65; Grass, *Crawley*, 55; Coulton, *Medieval Village*, 557; Hilton, *A Medieval Society*, 75–77; Hilton, *English Peasantry*, 141, 143, 145–46, 230; Hilton, *Class Conflict*, 104–05; Postan, *Essays*, 102; Hatcher, *Rural Economy*, 64; Frances Page, *The Estates of*

defining the main demarcation point between them. Heavy week-work was regular and extremely rigid among the tenants of many southern-eastern estates, especially those of Ely, Ramsey, Peterborough, Canterbury, Bury St. Edmunds, and Winchester, whereas the exceptions were hard to find. Certain northern-western estates (e.g., Worcester bishopric, Crowland Abbey, Spalding Priory) followed the same pattern, demanding one or two days week-work from half-virgaters or lesser tenants. But the vast majority of estates in places like Oxfordshire, Warwickshire, Derbyshire, Staffordshire, Devon, Cornwall, Northumberland, and elsewhere, failed to succeed in this respect and either had to settle for boonworks only, or decided to engage in a policy of commutations in exchange for insignificant amounts; it is characteristic that in the southwestern peninsula commuted labor services were rarely valued above 3s., usually much less, whereas in Bolton Priory (Harewood parish, 1263) the labor services of a holder of two bovates were valued at only 2s.8 1/2d. Kosminsky's analysis of the Hundred Rolls drew a sharp distinction between the two regions by concluding that villein labor services accounted for approximately 24 percent of total tenant payments in certain southern counties, reaching all the way up to 40 percent in large parts of the East Midland, the Home Counties, and East Anglia.[52] In contrast, labor dues were one-fifth of total payments in some western counties and considerably less than 10 percent in the north. The significance of these findings is that, as Kosminsky's research implies, the level of labor services is an excellent indicator of the size of total payments since the two were locked in a direct relationship.

Based on the regional variations of the appropriation mechanism, we can distinguish two models in regard to the processes of technological diffusion and economic growth. The first model, representing the quintessential medieval conservatism and stagnation, encompasses estates such as those of the Winchester bishopric and the abbeys of Ramsey and Westminster. In a monotonous repetition, the evidence reveals the simultaneous convergence of three features: a powerful network of extractions that took the form of labor supplies, produce, and money—certain Westminster manors generated at least half of their revenues through tallages and court perquisites[53]—along with a stagnant technical base and low yields. In such cases, there was no need to

Crowland Abbey (London, 1934), 79, 83, 99–100; Kershaw, *Bolton Priory*, 47; J. Jolliffe, "Northumbrian Institutions," *English Historical Review* 161 (1926):4–5; Dyer, "Social Structure: the West Midlands," 665; Hatcher, "Social Structure: South–western England," in *Agrarian History* 2, ed. Hallam, 678–79.

[52] Kosminsky, "Services and Money Rents," 43; see also Hilton, *A Medieval Society*, 127.

[53] Christopher Dyer, "Social Structure: the West Midlands," 667–68.

innovate since wealth was secured through means of political compulsion, as opposed to productive efficiency; in fact, the reliance of their demesnes on customary labor was a factor that, in itself, lowered efficiency standards.

One might get the impression that access to a substantial pool of unpaid labor would be a tremendous advantage both for the profitability of those estates and for the employment of labor-intensive techniques. It is apparently through this logic that we can explain the notorious zeal of the bishop of Winchester in getting labor services, as revealed in a 1270 document referring to his villeins: "if they be hindered by rain or in any other way, from doing their day's work, they shall come on the morrow; and if they be hindered on that day also, they shall come on the day following, and from day to day until they have fully completed one day's work."[54]

But access to customary labor had its great disadvantages, namely, a level of labor productivity that was far lower than that of hired labor.[55] In an economic activity such as agriculture, whose production cycle demands an accurate and rapid performance of tasks, usually within a limited time span, this type of inefficient work was bound to have disastrous effects on the level of output. The problem of poor performance was compounded by that of fraud evident in the numerous fines imposed on workers for stealing sheaves in the fields.[56] Since the villein did not have any incentive to increase his labor productivity, it follows that in order to gain even modest efficiency under this arrangement, it was imperative for the manor to spend substantial amounts on administration, accounting, and supervision.

Surely enough, we can point to the cases of certain estates that did exhibit signs of efficiency, despite their access to ample supplies of customary labor. Cuxham manor is the most exceptional case of all given its impressive yields and certain innovating practices such as the planting of legumes. But if we judge its performance not on the basis of the absolute level of yields—which would be unfair given its exceptional soil fertility—but based on a temporal perspective, then the picture is less flattering when we account for the dramatic decline of wheat yields. The period of decline coincides with an intensification of labor services that created discontent among villeins.[57] In addition, their labor was used within a rigid open field that practiced a three-course

[54] Cited in Coulton, *Medieval Village*, 557.

[55] David Stone, "The Productivity of Hired and Customary Labour: Evidence from Wisbech Barton in the Fourteenth Century," *Economic History Review* 50.4 (1997).

[56] Ault, *Open–field Farming*, 29, 92.

[57] Dyer, "Social Structure: the West Midlands," 668.

rotation. I would argue that the failure of its officials to rearrange fields and practice more flexible rotations was largely responsible for these developments.

The estates of Bury St. Edmunds and Christ Church also had access to plentiful supplies of customary labor, but instead of exhibiting signs of complacency and conservatism, they were in the forefront of innovation, adopting convertible husbandry, treating the soil with marl, planting large quantities of legumes, and occasionally raising their animal stock to adequate levels. The yields of individual manors were not always exceptional, but they certainly reached satisfactory levels overall given the intensity of cultivation. It becomes apparent that a model based solely on a class structure perspective does not possess sufficient explanatory power; it has to be infused with other considerations that I will refer to shortly.

But next to this group of estates, there was a second one with entirely different attributes that were defined by their weak prerogative toward extractions coupled with the adoption of progressive technologies that led to impressive yields; the abbeys of Tavistock and Battle, the Duchy of Cornwall, Bolton Priory, and a cluster of manors in eastern Norfolk are the best documented cases of this group. The particular settlement histories of those estates prevented the establishment of a strong seigneurial element and a rigid communalism. Battle Abbey, for example, was "early furnished with attendant bodies of wage-earning labourers and with fields virtually free of any collective restraints."[58] By implication, the officials of these estates could not rely on high seigneurial profits; for instance, Bolton Priory derived half of its revenues from the sale of wool, corn, livestock, and hides, and only one third from rents.[59]

This peculiar (for the standards of feudalism) social framework forced them, in a sense, to achieve survival or success by taking two distinct steps. First was the employment of wage labor that bore a cost price and hence did not favor its intensive utilization through such means as the lengthening of the working day, which could result in its inefficient use. But "for this type of cultivation to be of advantage . . . it was not sufficient that hired labour should be more efficient than compulsory serf labour. Productivity must have reached a certain *minimum level.*"[60] The second, and indispensable, step involved "long periods of

---

[58] P.F. Brandon, "Cereal Yields on the Sussex Estates of Battle Abbey During the Later Middle Ages," *Economic History Review* 15.3 (1972):405.

[59] Kershaw, *Bolton Priory*, 19.

[60] Maurice Dobb, *Studies in the Development of Capitalism* (New York, 1963), 55; the italics are Dobb's.

innovation and experiment"[61] evident in the adoption of flexible rotations, high seeding-rates, and the use of ample quantities of manure and conditioners. Medieval agrarian technologies were not particularly expensive—with few exceptions—nevertheless, the investment rates of such estates were occasionally higher than those of the less progressive group; Bolton Priory, for instance, dedicated 10 percent of its total cash expenditure for investment outlays, roughly double the rate of financially more powerful estates.[62]

If regional variations regarding the degree of seigneurial power were such a powerful force in conditioning the differences in the rates of technological diffusion and the level of crop yields, then what can be said about the role of demographic and commercial configurations in shaping the latter trends? Were demographic and commercial forces powerful enough to have gained the privilege of being the preeminent explanatory factor, or were these forces highly conditioned by variations in appropriation mechanisms and in the productive potential set by ecological features? To make some sense of these issues, we ought to start by justifying the hypothesis that the commercial and demographic profiles of the north-west and south-east were distinct enough to support the loosely-defined dualism that has been argued in previous pages.

There is no doubt that as the population curve continued its upward trajectory during the pre-plague decades, the southern-eastern region met some of the preconditions that were necessary for the unfolding of a Smithian scenario that views the market as a pulling force creating disequilibria that can be resolved by increasing output through innovation; such preconditions included an advanced river navigation system centered on the Thames and easy access to continental markets through coastal ports. As a result, the urbanization ratio was clearly higher than in the rest of the country, reflected in the location of the majority of towns with more than ten thousand people, including the bustling metropolis, in this region.[63]

Nevertheless, many estates across this part of the country failed to respond adequately to market stimuli because, no doubt, their power-

[61] Brandon, "Cereal Yields," 405.

[62] For a comparison of investment expenditures, see Miller and Hatcher, *Medieval England*, 232; M. M. Postan, "Investment in Medieval Agriculture," *Journal of Economic History* 27.4 (1967):578–79; Sidney Pollard and David W. Crossley, *The Wealth of England, 1085–1966* (New York, 1969), 40; Hilton, *English Peasantry*, 186, 188, 214; Kershaw, *Bolton Priory*, 120, 124–25.

[63] Campbell et al., *A Medieval Capital*, 9, 63–69; David Farmer, "Prices and Wages," in *Agrarian History* 2:743–44, especially table 7.3; John Langdon, "Inland Water Transport in Medieval England," *Journal of Historical Geography* 19.1(1993):4–5, 7–9.

ful prerogatives over their tenants already guaranteed a sizable wealth. The Winchester manors,[64] for instance, did sell grain, cheese, hides, fleeces and wood, but profits from such sources constituted a modest portion of their enormous total revenues. Of course, one may argue that many of the bishop's manors did not have easy access to London and it is precisely their weak market links that account for their stagnant technological infrastructure. On the other hand, some of the Winchester manors were linked with London via the Thames, disposing of large quantities of wheat; one such example is the Berkshire manor of Brightwell. Nevertheless, even in such cases the market failed to create backward pressures that would have led to technological innovation; Brightwell, for instance, retained a low-intensity two-course rotation in the context of a permanent arable-pasture regime that was bound to impact negatively on other techniques (e.g. manure management). In the end, not only did its yields—including those of wheat—remain mediocre, but they even showed signs of a temporal decline during the period 1271–1349. In the case of few other estates, the utilization of techniques did sometimes exhibit a stronger correlation with price movements, but it took place within the context of an inefficient system of labor management that reduced the potential effect of an improved "technological matrix." A typical case in point is Canterbury Cathedral Priory, which marketed a significant quantity of surplus grains to the London market, flourishing ports along the southeastern coastline, and even the Continent.[65]

The efficient estates of this region also developed considerable ties with markets. The intensive farming practiced in eastern Norfolk, for example, resulted in large surpluses of barley, which were sold, and similar developments took place in Sussex.[66] But would this cluster of southeastern manors have failed to innovate in the absence of London and continental markets? This question refers to a counterfactual situation and therefore is impossible to answer, but the present author is inclined to speculate that innovation would still have taken place. What makes such speculation highly plausible is the satisfactory performance of many western-northern estates despite the presence of

[64] For the Winchester estates, and Brightwell manor in particular, see David Farmer, "Marketing the Produce of the Countryside, 1200–1500," in *Agrarian History* 3, ed. Miller, 359–62, 401, 404, 411; Titow, *Winchester Yields*, 18; Bruce Campbell, "Measuring the Commercialization of Seigneurial Agriculture c. 1300," in *A Commercializing Economy, England 1086 to c. 1300*, ed. Richard Britnell and Bruce Campbell (Manchester and New York, 1995), 180.

[65] Mate, "The Agrarian Economy of Southeast England," 106; Smith, *Canterbury*, 128, 130.

[66] Searle, *Lordship and Community*, 274–75; Campbell et al., *A Medieval Capital*, 181–82.

fewer navigable rivers, which exposed them to a higher overland transportation cost, and a price structure that seems to have been less stimulating than that in the London region.[67] Of course commercial forces were not entirely absent. The economies of Devon and Cornwall,[68] for instance, certainly benefited from the increased demand regarding grains, animal products, and wool generated by the non-agricultural sectors (e.g., mining, cloth-making) of Cornwall, Dorset, Warwickshire, and Worcestershire. But such demand could not match the one emanating from London. Nor was it uniformly present throughout this region. In conclusion, the failure of the majority of western-northern estates to lay a claim on abundant labor supplies forced them to utilize hired labor, which bore a price, and this, in itself, created the incentive for innovation. In other words, a minimum degree of efficiency had to be achieved if production was to take place at all. Obviously, the degree to which market forces stimulated producers via price mechanisms could make the difference between decent yields and impressive ones—the contrast between Devon/Cornwall and the Craven area of Yorkshire illustrates this point—but the market was a conditioning factor for the degree of success, not its occurrence in the first place.

Bolton Priory,[69] for instance, established the fair of Embsay, but, judging from the revenues collected from the tolls, it attracted little interest from traders and customers. Both before and after 1300 (when data on yields are also available), the respective amounts remained nearly static at low levels. The record was set in 1297–98, but despite the officials' efforts to improve the situation by extending the duration of the fair, the first famines and the Scottish raids gave the final blow and by 1324–25 the revenues dropped to trivial amounts; nevertheless, the priory's yields were very satisfactory despite its access to very poor edaphic conditions.

* * *

The radical transformations that followed the wave of epidemics of the fourteenth century altered the fundamental variables of feudal society and had a profound impact on the institutional context that defined what Marx called the forces of production. There are two sets of questions that have to be addressed. First, can we establish a cause-and-effect relationship between the dynamics of technological diffusion, on the one hand, and the behavior of demesnial yields, which increased

[67] For sources, see the references to Langdon's and Farmer's works in n. 63.
[68] Hatcher, *Rural Economy*, 29–36.
[69] Kershaw, *Bolton Priory*, 29.

initially but followed a downward path during the first half of the fifteenth century? The second set of questions refers to the normative aspect of the debate. Are the post-plague contours of agrarian technology the outcome of a complex set of factors that encompass ecological profiles, class structures, and market/demographic forces as in the preplague period? If so, and given the ideal "matrices" defined by ecological characteristics, are the regional manifestations of the feudal class structure still the preeminent context of determination when it comes to the process of technological diffusion?

Looking at the latter process from a regional perspective, we can outline the gradual retreat of a number of techniques within the southern and eastern counties that affected both the more and the less efficient estates, although there were differences in terms of timing as well as a few exceptions to the overall trend. Many Sussex manors did follow the overall trend, albeit the signs of retreat took some time to manifest themselves.[70] During the second half of the fourteenth century, convertible husbandry made inroads into fields that previously used a conventional three-course rotation and retained an intensive character, with many manors substituting legumes in the place of fallow, and retaining seeding rates and the frequency of ploughing at high levels; legumes covered 20 percent of the demesne at Wye, 25 percent at Alciston, and 40 percent at Dengemarch and the lay manor of Chalvington. Stocking densities were also quite respectable in most of these manors, which led to adequate manuring that was often transferred from the barns even when some fields were leased to tenants; marling and sanding, however, became far more sporadic.

But the spirit of innovation did not last long. By the beginning of the fifteenth century, convertible husbandry was switched to a lower level of intensity, as in the case of Alciston, whose acreage under the plough was cut by half by the end of the century; the officials of Lullington and Apuldram followed similar policies, although the reduction was more moderate. But wherever the size of the arable was cut down dramatically, the whole system deteriorated to an infield-outfield arrangement; fields that were previously cropped continuously were now cropped intermittently every few years and in some cases (e.g.

[70] Edward Miller, "Introduction: Land and People," in *Agrarian History* 3, ed. Miller, 27; Mavis Mate, "The Occupation of the Land: Kent and Sussex," in *Agrarian History* 3, ed. Miller, 121; Mate, "Farming Practice and Techniques: Kent and Sussex," in *Agrarian History* 3, ed. Miller, 268–70, 272–75, 277, 281, 285; Mavis Mate, "Agrarian Technology in Southeast England in the late Middle Ages," paper presented at the Eleventh International Economic History Congress, Milan, September 1994, 2–4, 6–7, 9–14; Brandon, "Demesne Arable Farming," 132–33.

Alciston) even the infield was allowed to fallow. The organizational changes brought certain derivative outcomes regarding other techniques. Seeding rates were also scaled back, although they were still higher than elsewhere, but the animal stock seems to have been kept at satisfactory levels, perhaps not as a result of a conscious policy but due to the expansion of pastures. Whatever the reason, manuring was adequate, especially when we factor in the privilege of having tenants' sheep folding over the demesne during the night. Finally, the reduction of the arable affected the cultivation of legumes the most. As Mate suggested,[71] their cultivation seems to have established an inverse relationship with the extent of pastures, that is, the more the latter increased as arable contracted, the less need there was for fodder crops, a need that was never particularly pressing to begin with given the relatively small number of horses retained in demesnes. Evidence deriving from both Battle Abbey and lay manors (e.g. Laughton) shows the continued use of oxen for ploughing and even carting; horses were the preferred animal mainly for harrowing. This preference for oxen was somewhat of an anomaly in the context of the increased use of horses in the region during the fifteenth century, but it was not necessarily irrational given the increased availability of pastures.

Events in Kent followed a parallel trajectory.[72] Convertible became less intense, although perhaps not as low as in Sussex and with a significant time delay; i.e., it began around the middle of the fifteenth century. Infields were cultivated fairly continuously, whereas the resting period of the outfields depended on the soil's fertility; it ranged from three to five years at Barton, all the way to ten years in the Weald and the marshlands. Seeding rates fell in most manors after the Black Death (Barton was an exception until the middle of the fifteenth century), and so did labor inputs, a decision that may have affected adversely the thoroughness of weeding, carting manure, and ploughing. The gradual extension of pastures did not seem to benefit the level of stocking densities, given the mediocre rates documented for the manors of Barton, Wratham, and Otford during the first quarter of the fifteenth century. The use of legumes was one of the few techniques that stayed at high levels. In fact, their proportion may have increased over time; data from the late fourteenth century show legumes occupying 20 to 30 percent of the cultivated acreage in several manors, and similar numbers have been documented for the fifteenth century. Legumes continued to be used as an alternative to fallow and as fodder

[71] Mate, "Farming Practice and Techniques: Kent and Sussex," 270.

[72] Ibid., 268–69, 271–72, 275–76, 285; Mate, "Agrarian Technology," 2–6, 8–10, 14.

for horses; some manors (e.g., Otford, Wratham, Meopham) still retained some oxen, but it was in places like Monkton and Barton that the switch was made, shortly after the Black Death, to horses as the predominant draft animal of the county.

Of the remaining counties that formed the southeastern coastal arc, Norfolk retained the greatest degree of continuity with the past, whereas Essex revealed the least.[73] At Langehoe (Essex) rotations became less regular and the periods of rest were extended by the 1390s. Periods of rest were also extended in Norfolk, but the degree of intensity was not as low as elsewhere, especially in the light loams that kept producing large quantities of barley; at Ormesby St. Margaret, for instance, certain fields gave crops for eight or more consecutive years, and cropping at Martham was equally intensive. Similar distinctions emerge when it comes to certain labor-intensive practices. Weeding at Martham and marling in the Breckland were reduced, whereas ploughing at Eastwood (Essex) never exceeded half the fallow during the 1360s, but in some Suffolk manors of Bury St. Edmunds, ploughing was done twice or thrice during the summer. At Ormesby St. Margaret six times was common. The differences in the intensity of ploughing involve a cost that was far higher in Essex both because of its less workable soil and because the fallow was larger than that in Norfolk. Stocking densities and the extent of manuring also exhibited temporal and regional variations: at the Norfolk manors of Eaton and Plumstead, manuring was greatly reduced shortly after the Black Death; on the other hand, fifteenth-century data reveal that manuring, through the use of foldcourses or by carting, became more systematic as time went on; the use of folds, in itself, resulted in manuring a sixth of the land at Ormesby around the middle of the century. Finally, the cultivation of legumes does not seem to have made impressive advances, given a sample of thirty manors in the three counties showing a range around 7 to 8 percent. These numbers are somewhat at odds with the continuing, and perhaps increasing, preference toward horses, especially in Norfolk.

The rest of this region did not fare better, that is, the pace of technological diffusion did not show signs of speeding up considerably. The central-south and East Midland counties kept, by and large, a continuity with the past when it came to the organization of fields and rotations, that is, rigid open fields with the traditional two- and three-

[73] R. H. Britnell, "The Occupation of the Land: Eastern England," in *Agrarian History* 3, ed. Miller, 60, 62–63; Britnell, "Farming Practice and Techniques: Eastern England," 196–97, 199–200, 202–06; Campbell, "Agricultural Progress," 34, 38–39; Bailey, *A Marginal Economy?* 236.

course rotations remained the predominant forms.[74] There were some sporadic instances of consolidation, and even enclosure, that were accompanied by a reorganization of fields (some East Midland townships adopted an infield-outfield arrangement) and a shift of rotations. Ramsey Abbey reorganized the fields in some of its manors in Cambridgeshire and Huntingdonshire, introducing a four-course rotation that included legumes as the crop preceding wheat. Similar experiments, on a limited scale, have been documented for some Winchester and Glastonbury manors. But the slow pace of these changes deprived them of a substantial impact; the husbandry systems of most Winchester manors, for instance, showed no signs of change, and that took a toll on their revenues. Farmer has shown that manors that adopted a two-course rotation (Brightwell, Harwell, Adderbury) produced far higher wheat and barley yields than manors that retained, unnecessarily, an intensive three-course rotation (Ivinghoe, Wargrave, Waltham St. Lawrence), despite the evident exhaustion of the soil.

The various methods of treating the soil also exhibited wide disparities.[75] Ramsey Abbey, for instance, engaged in a conscious policy of building up the size of its sheep flock during the second half of the fourteenth century, despite great fluctuations due to recurring epidemics. Similarly, the officials of Westminster Abbey, and the Winchester manors under the guidance of William of Wykeham, succeeded in retaining more animal stock per acre sown compared with the preplague period; these developments resulted in more systematic manuring in the case of the Winchester manors, evident in the extensive use of labor services for this purpose, an effort that continued well into the fifteenth century, although the upward trend had halted by that time. But the effort did pay off as long as it lasted; based on Farmer's calculations, the manors with the highest animal density were the ones that increased their yields the most. On the other hand, marling virtually disappeared during this period, whereas the cultivation of legumes var-

[74] Edmund King, "The Occupation of the Land: the East Midlands," in *Agrarian History* 3, ed. Miller, 75; Britnell, "Farming Practice and Techniques: Eastern England," 198; Edmund King, "Farming Practice and Techniques: the East Midlands," in *Agrarian History* 3, ed. Miller, 219; P.D.A. Harvey, "Farming Practice and Techniques: the Home Counties," in *Agrarian History* 3, ed. Miller, 254–55, 258–59; Edward Miller, "Farming Practice and Techniques: the Southern Counties," 286–87; Farmer, "Grain Yields on Westminster Abbey," 345–47.

[75] Britnell, "The Occupation of the Land: Eastern England," 63; King, "Farming Practice and Techniques: the East Midlands," 210, 215–16, 220–21; Harvey, "Farming Practice and Techniques: the Home Counties," 260, 263, 266–67; Miller, "Farming Practice and Techniques: the Southern Counties," 289–90; Mate, "Agrarian Technology," 6; Titow, *English Rural Society*, 41; D.L. Farmer, "Grain Yields on the Winchester Manors in the Later Middle Ages," *Economic History Review* 30.4 (1977):564; Farmer, "Grain Yields on Westminster Abbey," 341, 343.

ied greatly even within the confines of a manorial nexus. Several East Midland counties such as Cambridgeshire, Northamptonshire, and Huntingdonshire were at the forefront of introducing them, but farther south there were no visible signs of a temporal increase; less than 7 percent of Winchester bishopric's acreage, for instance, was dedicated to legumes by the end of the fourteenth century. And it is doubtful they made much difference to yields because they were often sown before the fallow. Legumes remained primarily a fodder crop for horses and occasionally for oxen and sheep. The predominance of oxen continued during this period, although horses did make some inroads in demesnes, especially in Hertfordshire, accounting for about one third of the total number of draft animals in the central-southern counties and the East Midlands.

All in all, there is clearly a cause-and-effect relationship between the recorded demesnial yields and the technological choices made within the south-east during the post-plague period. The five coastal counties from Norfolk to Sussex continued for a while to be a showcase of efficiency by largely retaining intact their technological inputs and even extending them, as was the case with the adoption of convertible husbandry in parts of Sussex; the yields from Sussex and Norfolk, especially those of wheat and oats, testify to this effect. But during the fifteenth century convertible husbandry was geared toward a lower level of intensity, a development that was not negative in itself—in fact, it proves the flexible nature of the system—were it not for the retreat of certain technologies, such as legumes and marling; consequently, yields in general and wheat yields in particular were penalized, as is evident from the temporal behavior of the Sussex manors. East Midland landlords moved slightly toward the opposite direction, that is, a largely stagnant picture is occasionally interrupted by instances of innovation such as the rearrangement of fields and a further introduction of legumes. The estates that went far enough, such as Ramsey, produced excellent yields. It is interesting that as the counties along the south-eastern coastline retreated technologically and the East Midlands improved, there was a trend toward converging their efficiency levels, which were still higher than those of the estates in the central-southern part of the region. The latter retained their field arrangements, failed to improve their animal stock and the proportion of legumes on a consistent basis, and virtually abandoned marling. The gradual decrease of the wheat and barley yields in the Winchester manors is an illustration of these developments.

Similar developments took place in the western and northern counties with the possible exception of Devon and Cornwall, which, in some respects, fared even better than before. Perhaps the most impor-

tant change was of a structural nature: the continuing consolidation of holdings.[76] The beginnings of this phenomenon date back to the pre-plague period, but it was in a process of becoming that continued well into the fifteenth century, often accompanied by enclosures and the adoption of convertible husbandry. The new arrangements resulted in a far more rational allocation of resources and livestock management. At the same time, convertible husbandry became less intense with the extension of leys shortly after the great epidemic—several estates cropped between a quarter to half the size of the arable—and, in conjunction with certain techniques, produced excellent yields.

Additional contributing factors in sustaining high yields were continued systematic manuring and conditioning of the soil. Some of these practices were labor intensive, but they were still affordable given the reduction of the cultivated acreage.[77] Beat-burning, marling, and especially sanding, were practices so deeply embedded in the local routine that it is hardly surprising they continued to be used at an undiminished rate; sanding, in particular, was a significant source of employment for many people who handled its carriage by horses or barges to more inland locations. More important, stocking densities exhibited a spectacular upward trend in manorial estates from 1350 to 1500. Relevant data from several demesnes in both counties indicate that the number of animals per sown acre had more than doubled between the beginning and the end of the period; the abundant grass acquired through the extension of leys certainly had something to do with these improvements. On the other hand, seeding rates were not as high as elsewhere, although, wherever sanding was undertaken, weed growth was minimal and, therefore, there was no need for thick sowing. Finally, legumes were virtually non-existent, barely covering 2 percent of the cultivated acreage by the end of the fifteenth century; they were mainly grown in gardens, as opposed to being part of a rotational pattern.

The western parts of the Midlands followed a trajectory parallel to that of the eastern parts in the sense that there was some change over the pre-existing status quo.[78] Communal regulations that obliged farmers to follow a three-course rotation (in the north and west of the region) or a two-course one (in the north and east) were still deeply

---

[76] Fox, "The Occupation of the Land: Devon and Cornwall," 170; H.S.A. Fox, "Farming Practice and Techniques: Devon and Cornwall," in *Agrarian History* 3, ed. Miller, 309, 312, 315.

[77] Fox, "Farming Practice and Techniques: Devon and Cornwall," 304–05, 309–11, 313, 315; Titow, *English Rural Society*, 42.

[78] C. C. Dyer, "Farming Practice and Techniques: the West Midlands," in *Agrarian History* 3, ed. Miller, 223–25, 227, 233–34.

embedded in the agrarian routine, although some fields had irregular sizes and/or were enclosed. The process of "inhoking" part of the fallow and putting it under continuous cultivation for several years, thereby adding, in essence, an additional rotation, was a phenomenon that appeared before the epidemics and continued well into the fifteenth century. But there were often more radical deviations from the norm with the introduction of a more flexible infield-outfield arrangement, as in the Peak District of Derbyshire; in such cases we encounter the familiar interchanging role of fields every few years, that is, arable turning into leys or former grassland turning into arable for five to six years before returning again to grass. Documents do not always specify the exact nature of these changes, but there seems to have been a tendency to extend gradually the size of pastures at the expense of crops. The number of sheep in the estates of some prominent lay and ecclesiastical landlords (e.g., Duchy of Lancaster, Thomas Beauchamp, Worcester Cathedral Priory) may have been lower compared with their peak in 1300. Given the often drastic retreat of arable, however, the number of animals per sown acre may have ended up being somewhat higher. The proportion of legumes also increased and presumably had an impact in improving the quality of the soil.

Finally, similar changes took place in the northern counties, especially in husbandry systems.[79] Communal regulation in the context of traditional open fields was still the norm, as in most of Lincolnshire where two-field townships were in the majority, but it became increasingly difficult to enforce the respective regulations. At the same time, there was a growing, but still weak, tendency in parts of Lancashire and Yorkshire to enclose lands through the consolidation of holdings and the introduction of more flexible systems of land management. In Cumberland a gradual process of "inhoking" part of the outlying waste started in the fifteenth century, creating a type of "infield-outfield" arrangement. These encroachments of convertible husbandry into new areas and its preservation in places that had already adopted it in the pre-plague period (e.g. Bolton Priory) allowed a more rational and efficient use of animal and labor resources.

All in all, the process of technological diffusion in this region was quite stable, notwithstanding some signs of gradual improvement in certain localities. Change was less visible in the West Midlands and the northern counties, and may or may not have made a difference in the

[79] J. A. Tuck, "Farming Practice and Techniques: the Northern Borders," in *Agrarian History* 3, ed. Miller, 176–77; Edward Miller, "Farming Practice and Techniques: Yorkshire and Lancashire," in *Agrarian History* 3, ed. Miller, 186; Britnell, "Farming Practice and Techniques: Eastern England," 199; Kershaw, *Bolton Priory*, 66.

level of yields whose documented frequency is not high enough to support a definitive assessment. But we do know that yields were exceptional, for medieval standards, in Devon and Cornwall, the only counties in the country that kept making substantial improvements after the wave of epidemics in terms of applying conditioners, expanding animal stocks, and, most important, adopting various forms of convertible husbandry at an almost universal level.

The next set of questions we have to introduce before concluding this section concerns the interpretation of these developments. Do regional differences in class structures, market forces, and ecological conditions converge in shaping a multiple context of determination and, if so, does the significance of each factor shift over time? To answer these questions we have to begin by focusing on the initial decline and subsequent stagnation of the population curve that led to a wave of tenurial vacancies and affected particularly the large conservative estates, which had depended heavily on the labor services of tenants who had died. As the demographic changes unfolded gradually and became a structural feature of the economy, both the conservative estates and those that had previously relied on hired labor found themselves increasingly exposed to higher wage costs. The continuation of arable cultivation became questionable for two reasons: on the supply side, wages increased faster than grain prices,[80] whereas, on the demand side, the quantity of grains needed to feed the surviving population declined precipitously. The obvious choice was to lease part of the demesne piecemeal.

But leasing land after the Black Death was not always an option, particularly when it was of low fertility and burdened with customary obligations. Therefore, in addition to leasing, many estates opted for expanding their pastoral farming. The increase of livestock and wool prices did not match that of grain prices,[81] but, given the far lower labor and total operating costs of pastoral farming, it made sense to switch emphasis. With the onset of the fifteenth century, however, things became even more difficult. The price of wool peaked in 1400–10 at 4.20s. per stone but followed a downward path thereafter. It coincided with the simultaneous decline of the export trade, which was

[80] Taking 1340–47 as the base period, the average cost of reaping/binding increased by 45 percent in the period 1350–1400, of threshing and winnowing by 32 percent, and of mowing by 42 percent. At the same time, the price of wheat increased by 33 percent, of barley by 31 percent, and of oats by 24 percent. These calculations, and subsequent ones on the fifteenth century, are based on data from David Farmer, "Prices and Wages, 1350–1500," in *Agrarian History* 3, ed. Miller, 444 (table 5.1), 471 (table 5.8).

[81] The price of wool increased only by 6 percent in 1350–1400 compared with 1340–50, that of oxen by 20 percent, and that of cows by 15 percent. These calculations, and the data on the movement of prices during the fifteenth century, are based on Farmer, "Prices and Wages," 457 (table 5.4), 467 (table 5.7).

particularly severe in the middle years of the century; by implication, the profit squeeze led many estates to abandon sheep-farming. To make matters worse, the collapse of grain prices during the fifteenth century and the continuous increase of wages, albeit at a decelerating pace, gave the final blow to arable cultivation and signaled the complete abandonment or leasing of demesnes.

It has to be emphasized, though, that this general outline of events hides some very important regional particularities, relating to ecological and market conditions, that affected the manner and timing of the estates' response to those challenges. The fertility of the soil and the local level of grain and livestock prices were critical in defining profit margins and, by implication, the intensity of cultivation and the diffusion of certain technologies associated with it.[82]

Most of the conservative estates in the central-south and the East Midlands adopted a passive attitude that unfolded slowly as time went on. Although local prices for both grains and livestock remained initially at or above the national average, they responded by reducing the size of the arable.[83] Westminster Abbey, for instance, placed in the land market a large portion of its demesnes shortly after 1350, whereas in the Winchester manors the extent of the arable fell by approximately 20 percent during the second half of the century. It is interesting that despite the elimination of labor services due to vacant holdings, many Winchester manors actually utilized only a portion of the remaining ones; in other words, they could have continued with arable farming, but they chose not to. This choice became particularly evident by 1449, when only a tenth of the Winchester demesnes remained under the plough compared with a century earlier. At the same time, labor services became redundant and the wave of commutations intensified in the period 1410–40. By the mid-fifteenth century, it was virtually impossible for conservative estates to return to arable cultivation because the revenues they were getting from commuted works were far less than the cost of hiring labor. For instance, a North-Crawley farthing-holder was called to pay 4s. in 1448–49 for the commutation of 143 working days; with this amount of money the manorial officials would be able to hire a reaper for only 11 days, or a thresher for 16 days, or an unskilled worker (e.g. for weeding) for 32 days.[84]

---

[82] Subsequent references to the regional levels of grain and livestock prices are taken from Farmer, "Prices and Wages," 448 (table 5.3), 459 (table 5.5).

[83] Miller, "Introduction," 13; Edward Miller, "The Occupation of the Land: the Southern Counties," in *Agrarian History* 3, ed. Miller, 142–43; J.M.W. Bean, "Landlords," in *Agrarian History* 3, ed. Miller, 575, 580.

[84] Regarding the wage for reapers, I relied on Farmer's calculation for the 1440s of 10.45d. per acre, which I divided by 2.5, that is, the number of man-days needed to complete

It is true that sheep farming continued in the Winchester manors and picked up in the 1370s; there were twenty-two thousand sheep in the Wiltshire and Hampshire manors at the end of the century. But, by the turn of the century, sheep-farming also went through a period of decline, and a portion of the flocks was leased to tenants. By the middle of the fifteenth century the number of sheep had gone down to 60 percent of its level in the 1370s; a similar behavioral pattern has been documented for many other southern landlords.[85]

Beyond the deterioration of market conditions in the fifteenth century—the prices of most grains and livestock fell below the national average—a number of other factors are relevant for the demise of conservative estates in the south and the East Midlands. Their reliance on customary labor would seem to have provided a defense mechanism against the squeeze on profits; nevertheless, the performance of such work became increasingly unreliable with the growing discontent of tenants and, therefore, inefficient. This factor, coupled with the marginal nature of many lands in the south and the rigidity of field systems, led to the eventual disintegration of these conservative institutions.

Progressive estates along the southeastern coastline were more vulnerable to wage increases, given their lack of access to large quantities of customary labor; some of them were even located on poor marginal soils, which raised the cost of certain activities (e.g. ploughing), as was the case in Breckland and Essex. But, by and large, they were fortunate enough to be situated on commercial routes that connected them with London and continental markets.[86] Estates in Kent, Sussex, and Norfolk continued to use the same advanced technologies in the aftermath of the Black Death, and even during the fifteenth century—when their convertible husbandries became less intense—they exhibited a more frequent sensitivity to market stimuli.

A case in point is the Christ Church manor of Barton, whose

---

the task; it follows that each person was paid 4.18d. Regarding threshing, I took the average wage of 9.16d. for the 1440s (again from Farmer) that was paid for threshing three quarters of mixed grains and divided by the three people needed to perform this task in one day, therefore, 3.05d. per person. Finally, for tasks such as weeding I have adopted a rate of 1.5d. a day because it was done in seasons of lower labor demand. For the level of wage rates, see Farmer, "Prices and Wages," 471 (table 5.8). For the labor productivity rates in tasks such as reaping and threshing, see Ault, *Open-field Farming*, 28, 32, 38; Robert Trow-Smith, *English Husbandry* (London, 1950), 66; van Bath, "The Influence of Economic Conditions," 17. Van Bath estimates that fourteen bushels could be threshed per day, most of them oats; I have adjusted the number down to one quarter because the threshing of wheat and barley was more time-consuming. For the commutation rate at Crawley, see Gras, *Crawley*, 67.

[85] Miller, "Introduction," 13; Bean, "Landlords," 583; Miller, "The Occupation of the Land: the Southern Counties," 144–45; Miller, "Farming Practice and Techniques: the Southern Counties," 292.

[86] Mate, "Agrarian Technology," 1–2.

officials were able to sell wheat at 5s. a quarter and barley at more than 3s. after the harvest of 1445–46. These prices stood above the national average for the 1440s, and produced a profit of about twenty pounds for that year, whereas profits from pastoral farming fetched close to twenty-one pounds; the Barton officials did produce more grains than those needed internally, and, although pastoral farming is less complicated, did not switch to it completely. Elsewhere, for instance at Alciston, where the price of barley was the same, the decision was made to reduce the cultivated acreage down to the point of satisfying only internal needs. Which of the two manors represents more accurately the overall posture of progressive estates is difficult to tell, but the technological infrastructure of these estates seems to have adjusted better to the harsh circumstances of this period.[87]

The same conclusion was reached for the progressive estates of the northern and western region, especially those in Devon and Cornwall. The size of land actually tilled was reduced within the context of convertible husbandry, no doubt because of the relative decline of market activities shortly after the Black Death, which affected mostly marginal fields.[88] By the first half of the fifteenth century, however, the revival of non-agricultural activities in the regional economy of Cornwall created a new demand for foodstuffs and gave a boost to arable farming, as reflected in rising land values. The fisheries, the expansion of ports and of manufacturing concerns, played such a role in the southeastern part of the county, whereas tin mines had a similar impact in the western parts. Tavistock Abbey also took advantage of the growing demand for both grains and wool. All in all, producers in these two counties exhibited a remarkable continuity in the use of advanced technologies, which is partially explained by their readiness to respond to favorable market conditions.[89] This readiness is particularly evident in the demesnial animal ratios, which increased spectacularly in the midst of a buoyant market, with the exception of the first quarter of the fifteenth century, when the prices of wethers declined, indicating perhaps a temporary reduction of profit margins in sheep-farming.

Data on the process of technological diffusion in the West Midlands and the north are less plentiful, with the exception of changes in field

[87] Ibid., 13; Mate, "Farming Practice and Techniques: Kent and Sussex," 283–84.

[88] One aspect of this arable husbandry that seems very paradoxical is the heavy bias toward the cultivation of oats despite the low prices they fetched in the market, as opposed to wheat and barley, whose prices were above the national average. Oats were , however, not a cash crop, but were largely used in the making of bread and ale; hence, small quantities reached the market; see Fox, "Farming Practice and Techniques: Devon and Cornwall," 303–04.

[89] Ibid., 314, table 3.22; Finberg, *Tavistock Abbey*, 158; Hatcher, *Rural Economy and Society*, 258.

systems, but it does not seem to have followed the vitality of Devon and Cornwall. An indirect indicator is the rates of investment, which were not terribly different, on balance, from those of pre-plague standards, as is shown by the cases of two Warwickshire manors.[90] At Hampton Lucy (bishop of Worcester) the rate was 10 percent of the total revenue during the late fourteenth century, an amount spent mainly for the purchase of equipment, repairs of buildings, and enclosures. At the manor of Lighthorne, belonging to the Beauchamp family, the investment rate was 4 percent of the total cash receipts in the period 1390–1436. We should bear in mind that there was probably a significant inflationary component in these expenditures, and, in addition, they partially represent flows aimed at restoring the deterioration of fixed capital, as opposed to purchasing technological inputs capable of raising yields.

The lack of a strong interest in raising yields may be explained by the large expanses of marginal land and the weak nexus of commercial activities, with the exception of sheep farming in the Cotswolds and corn-growing in fertile, albeit isolated, pockets, e.g., in the valleys of Durham and Northumberland. In other words, the price structure in the product markets often did not justify the hiring of expensive labor. Nor did the existence of customary labor offer comfort, since it was often poorly performed and, therefore, inefficient. At the aforementioned manor of Lighthorne, for instance, *famuli* resisted the performance of several tasks in the 1390s. In the absence of extra hired labor, weeding did not take place, to the detriment of yields.[91]

In conclusion, the regional patterns of technological diffusion during the post-plague period continue to be the outcome of a complex context of determination. Ecological factors played a parametric function, since they determined techniques appropriate to each locality. But when it comes to the extent and intensity with which such techniques were used, it is the negative slope of the population curve and the commercial depression that followed that become of paramount importance. These developments had a powerful impact in shaping the temporal contours of relative prices in product and factor markets and, by implication, the extent of land's capacity utilization and the process of technological diffusion. We can even go a step further and argue that they were critical in triggering and sustaining the disintegration of feudalism's institutional structure by rendering labor the scarce factor of production, and thus allowing customary tenants to negotiate their status from a position of strength, eventually weakening the appropriation mechanism that tied them to a lord.

---

[90] Hilton, *English Peasantry*, 191–92, 196.
[91] Dyer, "Farming Practice and Techniques: the West Midlands," 231.

Does class structure thus become irrelevant in the process of technological diffusion? It is only fair to admit that when demographic and market forces lead to a weaker appropriation mechanism—in terms of legal status, the extent and forms of extractions, and the type of tenures—class structure loses part of its previous explanatory strength. But it is far from being irrelevant, especially when it comes to tenants, who came increasingly to control the extent of production and the process of technological diffusion. Given the rapidly increasing prices of many technological inputs, it would have been virtually impossible to afford most of them without succeeding in surrendering a lesser portion of their annual output as part of their seigneurial obligations. The significance of the institutional context can also be seen in relation to individual technologies. For instance, in order to take advantage of the potentially higher profit margins of pastoral farming, village communities should ideally have rearranged their fields and introduced some form of convertible husbandry. But in order to facilitate this process, they often had to discard the communal features of the open-field system and enclose fields, in other words, alter the property and institutional framework of the entire township. The pricing mechanism of the market provided an incentive for those changes to take place, but incentives do not act in a social vacuum.

* * *

The present paper has sought to establish the validity of two closely related hypotheses. First, there is a causal relationship between the ebbs and tides of technological diffusion paths and the level of productivity yields (and, by implication, of medieval growth dynamics), the former being the main determinant of the latter. This hypothesis can be tested both from a temporal and a regional perspective. In temporal terms, we pointed to the decline of yields during the century leading to the Black Death, reaching their lowest level throughout the entire examined period, an event that relates to the sluggish growth of technological inputs, which failed to match the extension at the margin of cultivation. Diffusion rates were particularly sluggish for convertible husbandry, animal stock rates, and legumes, in other words, for techniques that were capable of reversing the downward movement of yields. The same relationship between technological diffusion and growth patterns emerged in the post-plague period, when the former stabilized while land was withdrawn from cultivation during the second half of the fourteenth century, resulting in an increased ratio of technological inputs per sown acre, and hence in a modest recovery of yields. This trend, however, was short-lived and showed signs of reversal with the onset of the fifteenth century and the retreat of pastoral

farming. In regional terms, the relationship between technology and economic growth is established by looking at the closer conformity of the western and northern counties to a set of technological inputs deemed ideal for their particular ecological profiles. This closer conformity led them to achieve higher yields per seed and perhaps per sown acre,[92] while the rest of the country failed to do so.

The proponents of the Neo-Malthusian argument, and Postan in particular, did realize the potentially strategic role of technology in determining overall growth rates and preventing England from reaching its Malthusian ceiling. Nevertheless, they failed to make the very crucial distinction between the innovation of new technologies and the diffusion of existing ones; the absence of the former during the period 1200–1500 led them to disregard the significance of the latter. It was a small step, therefore, to accept the Ricardian proposition that technical change in agriculture cannot match the equivalent process in industry. Having excluded technology from its theoretical framework, the research agenda of the Neo-Malthusian school was bound to ignore both the temporal and regional manifestations of technological diffusion. The existing evidence can no longer support such a perspective.

But the proponents of the school still needed to specify the force(s) that drove the system to its full maturity and eventual disintegration. In addressing this issue, they opted for a monocausal explanation. The argument went that as the slope of the population curve increased, it triggered a colonization movement that kept driving the system to its demise, since the process could not go on indefinitely. The bonds that tied lords and tenants were largely irrelevant because the extension into marginal lands was unavoidable. The recovery of yields and growth rates was reserved for the post-plague period while the population curve followed its downward trajectory. Postan's failure to expand the conceptual range of his interpretation led to several discrepancies between his theory and the existing empirical evidence, particularly his prediction of a slow but gradual improvement of yields during the post-plague period. In fact, yields behaved quite erratically, which seems to suggest a more complex context of determination.

The present paper has attempted to establish such a context by proposing a second hypothesis that can be formulated as follows: population growth, market forces, tenurial arrangements, and ecological profiles are all indispensable components of the process of technological diffusion and, through it, the overall dynamics of the system. However, these variables should be examined not in isolation, but as part of

[92] Nevertheless, it has to be emphasized once more (see also n. 41) that high yields per seed and per sown acre do not necessarily translate to a high total output if fallowing is extensive.

a coherent theory that uncovers the interaction mechanisms that defined their complex relationship, mechanisms that shifted and evolved over time. The starting point of the analysis should be the definition of a standard against which the technological and growth patterns of a region, and of the country as a whole, ought to be judged. Such a standard, though, cannot be singular and absolute, but must be defined in relation to the limits set in each locality by its particular ecological profile; it follows that so-called "marginal" areas should not be evaluated according to the high standards set in the exceptionally fertile soils of parts of Kent and Norfolk, since the utilization of certain technologies in the former areas may not have been warranted given the diseconomies of scale encountered at lower levels of output.

Ecological profiles set points of reference, but the actual process of technological diffusion that unfolded during this period demands a wider array of variables that refer to institutional and social developments. Demographic growth during the pre-plague period brought a growing demand for foodstuffs. In a capitalist economy, this growth of demand would have created backward pressures that, through a Smithian scenario, would have ended by revolutionizing the forces of production. But in medieval England it was impossible for such a scenario to unfold in its full potential. The majority of estates relied heavily, not on the realization of commercial profits, but on the appropriation mechanism that tied them to their tenantry. The growth of population and demand could have had a long-lasting impact only in the context of a mechanism of wealth distribution that allowed tenants to retain a larger portion of their annual output and, simultaneously, forced landlords to innovate in order to expand their wealth. But for something like this to take place, landlords would have had to surrender their prerogative over the land and its output; that is, they would have had to give up their preeminent source of power and prestige. There is no evidence that such an option was voluntarily contemplated during this period; on the contrary, the appropriation mechanism took on its most rigid form. Of course, the strength of seigneurial power was not uniform across the country; in areas of liberal social conditions aspects of a Smithian scenario did unfold, although its extent was highly conditioned by local ecological constraints.

It was only during the post-plague period, with the weakening of the appropriation mechanism, that the market emerged as a potential engine of sustained growth. But the movement of relative prices in the product and factor markets postponed the realization of this potential until the onset of the Tudor dynasty. It was only then that the recovery of population was robust enough to have stimulated commercial expansion in the context of the emerging capitalist relations of production.

Appendix
Medieval demesnial yields, 1200–1500: yields per seed/yields per acre (in parentheses)

*Location**	*Sample period*	*Wheat*	*Barley*	*Oats*
Period 1: 1200–49				
Winchester manors (38), A	1200–49	3.8	4.4	2.6
Period 2: 1250–99				
Westminster manors (16), A	1271–99	3.27	3.63	2.37
Winchester manors (39), A	1250–99	3.8	3.5	2.3
Cuxham manor, Oxfordshire, B	1289–99	8.3	5.6	3.3
Oakington manor, Crowland Abbey, Cambridgeshire, A	1271–1320	5	4.8	2.6
Bec Abbey, A	1294–99	3.2	2.9	1.4
Hinderclay manor, Bury St. Edmunds, Suffolk, A	1272–93	5.37		
Newport manor, earl of Cornwall, Essex, A	1296	(c.10)	(c.6)	
Average of Sevenhampton and Stratton manors, Wiltshire, A	1273–88	4.4	6.8	2.8
Harewood manor, Yorkshire, B		(13–14)	(20–28)	
Cockermouth manor, Cumberland, B		(7)		
Birkby manor, Cumberland, B			(10)	
Eastern Norfolk (44 demesnes), A	1255–1349	4.5 (13.3)	3.1 (14.7)	2.7 (13)
Period 3: 1300–49				
Westminster manors (16), A	1300–49	2.92	4.1	2.34
Winchester manors (39), A	1300–49	3.9	3.6	2.2
Christ Church manors (5), Kent, A	1300–48	3.26–3.5 (8.75–14)		2.3–2.7 (6–22)
Cuxham manor, Oxfordshire, B	1300–49	6.24	5.78	3.7
Bolton manors (7), Yorkshire, B	1301–18	c.4–5	c.4–5	c.2–3
Ottery manor, Tavistock Abbey, Devon, B	1335–43	4.7		3.7–4.7 (28–30)
West Harling manor, East Anglia, A	1328–36		2.45 (8.6)	3.4 (9.7)
Wretham manor, East Anglia, A	1302–39	7.3 (14.7)	2.5 (10.2)	2.6 (10.1)

(*Continued*)

Appendix (*Continued*)

*Location**	*Sample period*	*Wheat*	*Barley*	*Oats*
Blakenham manor, Bec Abbey, Suffolk, A	1300–39	2.4	2.3	1.7
Cringleford manor, Norfolk, A	1333–48	8.8	4.5	2.5
Hinderclay manor, Bury St. Edmunds, Suffolk, A	1295–1310	4		
Redgrave manor, Bury St. Edmunds, Suffolk, A	1323–50	3.73–4		
Calthorpe manor, Norfolk, A	1332–47	4–9.7	3.1–5.9	5–9.6
Silkstead manor, Hampshire, A	1331–2	5		
Basingstoke manor, Hampshire, A	1333–6	3.7	2.4	1.5
St. Swithun Priory, Winchester (6), A	1325–31	3.9		
Temple Thornton manor, Northumberland, B		(4)		(7)
Period 4: 1350–99				
Beddingham manor, Battle Abbey, Sussex, A	1362–88	4.6 (10)	2.8 (11.75)	3.32 (11.5)
Alciston manor, Battle Abbey, Sussex, A	1356–93	4.96 (12.89)	3.16 (14.78)	3.5 (13.03)
Lullington manor, Battle Abbey, Sussex, A	1361–99	3.72 (9.8)	2.72 (13.68)	3.57 (15.4)
Dengemarch manor, Battle Abbey, A	1372–87		3.89 (14.35)	3.03 (16.2)
Barnhorne manor, Battle Abbey, A	1374–86	3.61	3.91	3.22
Westminster manors (16), A	1350–1410	3.04	4.06	2.66
Eastern Norfolk (30 demesnes), A	1350–1431	4.2 (12)	3.2 (15.6)	2.7 (13.2)
Winchester manors (38), A	1349–1410	3.77	3.83	2.68
Cuxham, Oxfordshire, B	1350–59	4.3		2.1
West Harling manor, East Anglia, A	1367–77	3.2 (7.7)	3.6 (10.9)	2.7 (7.8)
Ketton manor, Durham, B	1371–77	4.31	4.69	
Cowpen Bewley manor, Durham, B	1371–73	4.25	5.73	
Farleigh Hungerford manor, Somerset, A	1380s	c.7	5.3–6.3	
Temple Thornton manor, Northumberland, B		3.5		7
Claret Hall manor, Essex, A	1350–63	3.4		

(*Continued*)

Appendix (*Continued*)

*Location**	*Sample period*	*Wheat*	*Barley*	*Oats*
Eastwood manor, Essex, A	1363–73	3.7		
Langehoe manor, Essex, A	1381, 1396	3.7		
Risby manor, Suffolk, A	1352–77	3.9		
Ramsey manors (6), Huntingdonshire, A		4.5		
Warboys manor, Ramsey Abbey, Huntingdonshire, A		5.9	7.8	1
Meopham manor, Kent, A	1370s	c.2.5		
Higham Gobion manor, Bedfordshire, A	1380s	3.4		
Devon and Cornwall manors (33), B	1354–1500	5.28	4.18	3.52
Copton manor, Christ Church, Kent, A	1360s, 1370s	c.3	c.2	
Period 5: 1400–49				
Winchester manors (36), A	1411–53	3.66	3.64	3.03
Alciston manor, Battle Abbey, Sussex, A	1396–1452	4 (11)	3.11 (13.28)	4.09 (16.44)
Lullington manor, Battle Abbey, Sussex, A	1399–1469	3.08 (8.96)	2.99 (11.84)	5.42 (14.64)
Bidford–on–Avon manor, Bordesley Abbey, Warwickshire, B	1448		c.8	
Barnhorne manor, Battle Abbey, A	1400–69	2.98	3.55	3.7
Fornham All Saints manor, Suffolk, A	1400–20	2.9		
Ormesby manor, Norfolk, A	1423–52	4.8		
Apuldram manor, Sussex, A	1420–50	4.01 (8.78)	3.41 (13.66)	3.52 (14.1)
Barton manor, Christ Church, Kent, A	1445–47	4.06	6.1	6.45
Period 6: 1450–99				
Granchester manor, King College, Cambridgeshire, A	1455–65	3.3	3.3	1.6–2.3
Barnhorne manor, Battle Abbey, A	1460–94	3.83		3.61
Barton manor, Christ Church, Kent, A	1444–72	(14.87)	(23.37)	(22.2)

(*Continued*)

Appendix (*Continued*)

*Location**	*Sample period*	*Wheat*	*Barley*	*Oats*
Alciston manor, Battle Abbey, Sussex, A	1442–92	4.34	3.24	4
Apuldram manor, Sussex, A	1450s	5.33 (10.06)	3.37 (13.5)	4.2 (16.8)
Sir John Scott's farm at Mote, A	1475–80	7.66		4.39

*The various manors have been classified into two regional groups, A and B, based on the distinction adopted in the main text; group A includes southern and eastern manors, group B those in the west and north. The Westminster manors have been included in group A because that is where twelve manors (out of 16, in Farmer's sample) were located.

Sources: Titow, *Winchester Yields*, 4, table 1, and Farmer, "Grain Yields on the Winchester Manors," 560, table 3 (Winchester manors); Farmer, "Grain Yields on Westminster Abbey," 335–36, tables 1a, 1b, 1c (Westminster manors); P.D.A. Harvey, *A Medieval Oxfordshire Village: Cuxham, 1240–1400* (London, 1965), 57–58, table 4 (Cuxham and Ottery manors); Frances Page, *The Estates of Crowland Abbey* (London, 1934), 329–30 (Oakington manor); B. H. Slicher van Bath, *The Agrarian History of Western Europe, A.D. 500–1850*, trans. Olive Ordish (London, 1963), 328, table 2 (Granchester and Blakenham manors, and Bec Abbey); B.M.S. Campbell, "Arable Productivity in Medieval England: some Evidence from Norfolk," *Journal of Economic History* 43.2 (1983): 384, table 1 (Eastern Norfolk demesnes); Mate, "Medieval Agrarian Practices," 23, 26, table 1 (five Christ Church manors); Kershaw, *Bolton Priory*, 39–41, table 3 (Bolton Priory manors); Bailey, *A Marginal Economy?* 101–05, tables 3.3a, 3.3b (West Harling and Wretham manors); Brandon, "Cereal Yields," and Mate, "The Agrarian Economy," 81 (manors of Beddingham, Alciston, Lullington, Dengemarch); Hallam, "Farming Techniques: Eastern England," 291–92, 303 (manors of Cringleford, Hinderclay, Redgrave, Calthorpe, Newport); Hallam, "Farming Techniques: Southern England," 353 (manors of Silkstead, Basingstoke, St. Swithun Priory, Sevenhampton, Stratton); Miller, "Farming Techniques: Northern England," 407 (manors of Harewood, Cockermouth, Temple Thornton, Birkby); Tuck, "Farming Practice and Techniques: the Northern Borders," 179 (manors of Ketton, Cowpen Bewley, Temple Thornton); Britnell, "Farming Practice and Techniques: Eastern England," 207 (manors of Claret Hall, Eastwood, Langehoe, Fornham All Saints, Risby, Ormesby); King, "Farming Practice and Techniques: the East Midlands," 216 (Huntingdonshire manors of Ramsey Abbey, including Warboys); Harvey, "Farming Practice and Techniques: the Home Counties," 262 (Higham Gobion manor); Mate, "Farming Practice and Techniques: Kent and Sussex," 278, 280 (manors of Barton, Alciston, Apuldram); Fox, "Farming Practice and Techniques: Devon and Cornwall," 308 (thirty-three Devon and Cornwall manors); Mate, "Agrarian Technology," 5–6, 9, 15 (manors of Barton, Copton, Meopham, and Sir John Scott's farm); Dyer, "Farming Practice and Techniques: the West Midlands," 231 (Bidford-on-Avon manor); Edward Miller, "Farming Practice and Techniques: the Southern Counties," in *Agrarian History* 3, ed. Miller, 288 (Farleigh Hungerford manor).