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THE EFFICIENCY AND DISTRIBUTIONAL CONSEQUENCES OF EIGHTEENTH CENTURY ENCLOSURES*

Robert C. Allen

Between the fifteenth century and the nineteenth century the open fields of England were enclosed. Although the consequences of enclosures have been the subject of controversy since the process began, the proximate cause of enclosure has always been clear. Enclosures were invariably initiated by landowners because they expected their tenant farmers would pay higher rents after the parish was enclosed (Chambers and Mingay (1966, p. 8) and Tate (1967, p. 154)). The landowners' expectations seem generally to have been fulfilled. The great mystery is why rents rose. There are two possibilities: first, enclosed farming was more efficient than open field farming, so enclosed farms could afford to pay a higher rent. In that case the rise in rent indicates the rise in efficiency upon enclosing. Second, enclosures might have redistributed income from farmers to landowners. When land was enclosed, the existing leases were replaced by newly negotiated ones. If open field farms had been let at rents less than the value of the marginal product of land, then the rise in rents might simply indicate a redistribution of income (Yelling, 1977, pp. 209–13).

Eminent historians have championed both possibilities;[1] however, the evidence which they have brought to bear on this issue has not been sufficient to distinguish between these alternatives. In this paper the impact of enclosure will be assessed on the basis of statistical returns for 231 farms collected by Arthur Young in his tours of England in the late 1760's. The results would have surprised Young, who was an influential proponent of the view that enclosure increased efficiency, for they show that in the late eighteenth century, the enclosure of open field arable did not have that effect. Instead, enclosure caused a massive redistribution of income from farmers to landowners.

Arthur Young was secretary of the Board of Agriculture, editor of the *Annals of Agriculture*, and author of numerous books and pamphlets. He was one of the most prominent 'agricultural improvers' of the late eighteenth century. In 1768–70, early in his career, he travelled throughout England. His observations of farming practice and rural economy were embodied in nine volumes totalling 4,500 pages (Young, 1769, 1771, 1967). In these books Young presented detailed

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[1] Ernle (1961) vigorously supports the view that enclosure raised efficiency; Hammond and Hammond (1924) that enclosure redistributed income.

and uniform descriptions of agricultural practices in the villages he travelled through. In many cases he reported the 'particulars of representative farms'. The particulars included the actual rent the farmer was paying as well as enough information to estimate the prices or opportunity costs, and quantities of all of the inputs (including those supplied by the farmer such as farm family labour), and products of the farms. Young appears to have been careful and thoughtful in collecting his data. When judgement was required he proceeded in ways in which a modern economist would approve. For instance, wage rates frequently included payments in kind. Young valued these payments at local retail prices and added them to the money payment to obtain the wage (Young (1769), p. 320; (1771), vol. IV, pp. 311–2; and (1967), vol. II, pp. 292, 297). Thoroughness of this sort commends the data Young collected as the basis for a serious study of enclosure.

Nonetheless the data are not without their difficulties. Some difficulties are a result of incompleteness on Young's part. He did not, unfortunately, detail the quantity of every input and output used on every farm. It was necessary to impute values of some variables (like crop yields) reported for a village to all of the farms in the village. Young failed to report the quantities of some inputs (e.g. implements) so their quantities were estimated on the basis of various farm accounts. These estimation procedures are described in the Appendix.

A second sort of difficulty is a consequence of the organisation of eighteenth century farms. The common was an important component of the land input on many farms, especially open field farms. Since commons were used jointly by several farms, it is impossible to reduce their size to an acreage that can be added to the other land of the farm. Later in the paper, indices of the characteristics of land are used to incorporate commons into a measure of the land input.

In interpreting the results, the geographical distribution of the farms must be kept clearly in mind. From one point of view, the location of the farms is desirable. There were many in East Anglia, reputedly the most efficient region. Most of the farms were situated in the Midlands or in the northern counties of Yorkshire, Durham, and Northumberland. With the exception of the latter county, this was the classic region of open field farming (Gray, 1915) and includes the districts where parliamentary enclosure was most intense. On the other hand, the variation among the farms in soil and environmental characteristics is not as great as the geographical spread might suggest. The farms were mixed farms; the sample lacks farms in permanent pasture districts.[1] Moreover, while some farms were located on heavier soils than others, none of the farms were situated on the really heavy boulder clays where the cultivation of turnips was impractical. Consequently, Young's data do not illuminate the efficiency gains (if any) of enclosure where the result was the conversion of land to permanent pasture or the installation of better drainage systems (Vancouver, 1794, 1795). What we do observe is the effect of enclosure in areas where farming remained heavily arable

[1] Young did report on a few purely grassland farms but they were too few to support the sort of analysis reported here and so have not been included in the sample. Also farms located in Cumberland, Westmoreland, Lancashire, and Cheshire have not been included since their natural environments were so different from the rest of the country.

and where the introduction of turnips and clover into farm management was the basis of advance. Since the history of the agricultural revolution has often been told in terms of the diffusion of these crops, the results are still of considerable interest.

In assessing the results, one ought also to consider the representativeness of the data. The farms do not constitute a random sample; however, randomness is not necessary for this study since its aim is not to estimate unconditional population parameters like the average yield of wheat in England. Instead, the object of the study is to estimate parameters like farm efficiency *conditional on a farm's being open or enclosed*. Thus it is immaterial, for instance, if Young visited a disproportionate number of enclosed villages as long as he did not systematically search out enclosed villages more efficient than the average enclosed village or open field villages less efficient than average. Given Young's belief that enclosure raised efficiency, such a sampling strategy is the most likely way he might have been non-random. The results reported in this study hardly support that possibility. One remark in the preface to the *Northern Tour* does suggest that many of the farms were included because they shared one characteristic in common. Young reports that he arranged much of that tour when he met landlords at the annual horse races in York (Young, 1967, vol. I, pp. v–vi). It is difficult to see how that selection criterion might have biased the conditional distributions studied here.

The 231 farms that comprise the data used in this study are treated as one cross section. Of the farms 159 are classed as enclosed, 27 as open, and 45 as partially open. Enclosed farms are ones in which all the arable was enclosed. Open farms are ones in which the arable was predominantly open. Farms classed as partially open contain appreciable quantities of both sorts of land. This latter class was created in recognition of the fact that by the late eighteenth century piecemeal enclosure had made appreciable inroads into the fields of many villages. The distinction between enclosed farms, on the one hand, and open or partially open farms on the other, is sharp. In contrast, the distinction between open and partially open is fuzzy. Even the most pristine open village contained some enclosed land, and many villages classed as partially open were subsequently enclosed by Parliamentary Act. In this study, a conservative course has been followed, and farms were classified as open only if they appeared quite undisturbed by piecemeal enclosures. It should be noted that the empirical results presented subsequently usually show open and partially open farms to be similar to each other and decisively different from enclosed farms.

I. THE SCOPE FOR REDISTRIBUTION

Rents rose when villages were enclosed either because the efficiency of agriculture increased and hence the value of the land rose or because open field rents were less than the value of the land and rents were raised at enclosure to eliminate the disequilibrium. The crucial first step in distinguishing between these hypotheses is to compare the rents paid with the value of the land. This comparison can be made using the data Arthur Young collected since for each farm it is possible to compute the Ricardian surplus, i.e. revenues minus the opportunity cost of all non-land inputs, and compare it to the rent actually paid. When making this comparison, it is also necessary to include tithes and rates, the principal taxes. Their burden was light and, in this study, is presumed to have fallen entirely on land. Under this assumption, the test for competitive equilibrium in the land rental market is that rents were bid up to the level such that surplus minus rent

Table 1

Farmer's Surplus per Acre

Farmer's surplus per acre (£)	Number of farms		
	Enclosed	Open	Partially open
Less than −1·5	4	—	—
−1·0 to −1·5	4	—	—
−0·5 to −1	13	1	3
0 to −0·5	46	2	6
0·5 to 0	38	3	11
1·0 to 0·5	31	5	6
1·5 to 1·0	8	7	7
2·0 to 1·5	5	5	6
2·5 to 2·0	5	1	1
3·0 to 2·5	4	1	3
3·0+	1	2	2
Number	159	27	45
Mean farmer's surplus per acre	0·2351	1·2233	0·8847

Farmer's surplus equals a farm's surplus minus taxes and tithes paid minus the rent actually paid.

Table 2

Surplus, Efficiency, and Prices

	Surplus per acre (£)	Rent per acre (£)	Tithes and taxes per acre (£)	Farmer's surplus per acre (£)
Open	2·16	0·73	0·21	1·22
Partially open	1·62	0·57	0·17	0·88
Enclosed	1·00	0·65	0·12	0·24

Notes

Surplus per acre equals the farm's revenues per acre minus the opportunity cost of all non-land inputs per acre. Rent per acre equals the rent actually paid. Farmer's surplus per acre equals surplus per acre minus rent per acre minus tithes and taxes per acre.

minus taxes, which I shall call farmer's surplus, equalled zero. If this condition is satisfied for both open and enclosed farms then it is likely that enclosure raised rents by raising efficiency. On the other hand, if farmer's surplus equalled zero for enclosed farms but was positive for open farms, then the rise in rents that accompanied enclosure probably indicates a redistribution of income.

Table 1 shows the frequency distribution of farmer's surplus per acre for enclosed, open, and partially open farms. The distribution for enclosed farms is centred near zero with a mean of £0·2351 per acre. In contrast, farmer's surplus is positive for almost every open or partially open farm and the means of those distributions are £1·2233 and £0·8847 per acre respectively. In all cases (even enclosed farms) the null hypothesis that the means of the populations equal zero can be rejected. However, the magnitude of the divergence from equilibrium is very small in the case of enclosed farms. Indeed, since in these calculations the farmer's time was valued only at an agricultural worker's wage, the computed farmer's surplus per acre of £0·2351 in enclosed farms may indicate a return to the farmer's entrepreneurship. The hypothesis that the mean farmer's profit per acre is equal for the three kinds of farms can easily be rejected given the test statistic $F(2, 228) = 14{\cdot}947$.

Table 2 shows the mean surplus per acre, rent per acre, and taxes per acre for the three kinds of farms and puts the degree of disequilibrium into perspective. In open and partially open farms, rents absorbed about one third of the surplus. If rents in these farms were increased to absorb all the surplus, they would rise by a factor of $2\frac{1}{2}$. This result is consistent with the conventional wisdom of the eighteenth century that enclosure doubled or trebled rents.

The numbers in Table 2 are also consistent with conclusions drawn in the Board of Agriculture's *General Report on Enclosures* (Young, 1808). In discussing the impact of enclosure on farmers, the *Report* notes:

> If profit be measured by a percentage on the capital employed, the old system [open field arable] might, at the old rents, exceed the profits of the new [enclosed]; and this is certainly the farmer's view of the comparison.[1]

If one imputed the farmer's surplus shown in Tables 1 and 2 to the capital invested by farmers, the implied rates of return would be in accord with this observation.

II. PRICES AND EFFICIENCY COMPARISONS

These results indicate that enclosure offered considerable scope for the redistribution of agricultural income. The results do not preclude the possibility that enclosure also raised farm efficiency, a possibility now to be explored. This inquiry is made urgent by other aspects of Table 2. The table shows that, strangely, rents per acre were similar in open and enclosed farms:[2] the reason rents could be increased when farms were enclosed was not that open field rents were low but rather that the surplus per acre of open field farms exceeded the surplus of enclosed farms. If surpluses measure efficiency, then the implication of Table 2 is that enclosure lowered farm efficiency. This implication is not only inconsistent with everything that is known about eighteenth century farming, but it is also inconsistent with the movement of rents since it suggests that the disequilibrium in the open field rental market would be eliminated by surpluses falling rather than by rents rising.

[1] Young (1808, pp. 31–2). It should also be noted that, in contradiction to this conclusion, the *Report* (*ibid.*, pp. 37–8) also argues that the rise in rent indicates a rise in efficiency. Recently McCloskey (1972, 1975) has elaborated the argument that the rent rise indicates a rise in efficiency.

[2] Yelling (1977, p. 210) notes the same phenomenon in comparing rents in 'Common-field' parishes and 'enclosed "arable"' parishes in Rutland.

A major reason for the curious pattern in Table 2 is the treatment of common rights. They have thus far been ignored. The divisor in the calculations is a farm's acreage of arable and grass. Since common rights were particularly extensive for open and (to a lesser degree) partially open farms, surplus per acre for these farms is artificially raised relative to enclosed farms.[1] In addition, there are two factors other than the quality of the farming that might account for the lower surplus per acre of enclosed farms. Either the enclosed farms were less favourably located so that on average they faced lower output and higher input prices (the von Thünen effect), or they were located on poorer land than the open field farms (the Ricardo effect). Either effect would cause open field farms to generate higher surpluses per acre even if the two farming systems were intrinsically of the same efficiency. This section is concerned with assessing the importance of the von Thünen effect by examining how efficiency differences can be inferred from surplus differences in the face of varying input and output prices. In this section the assumptions that land was homogeneous and that common rights did not vary across farms are maintained. These assumptions are relaxed in the next section.

To develop a procedure for decomposing surplus per acre variations into price and efficiency variations, it is necessary to develop an economic model of a farm. Imagine the farm to possess a particular acreage of land, L, and to face exogenous product prices $P = (P_1, \ldots, P_m)$ and variable input prices $W = (W_1, \ldots, W_n)$ for all inputs besides land. These inputs are regarded as variable. Suppose the farm has a neoclassical technology and the farmer chooses to produce those outputs $Q = (Q_1, \ldots, Q_m)$ and to utilise variable inputs $X = (X_1, \ldots, X_n)$ that maximise Ricardian surplus, $S = \Sigma_{i=1}^{m} P_i Q_i - \Sigma_{i=1}^{n} W_i X_i$. In that case, maximised Ricardian surplus is a function[2] of P, W, and L: $S = S^*(P, W, L)$. Suppose further that the technology set exhibits constant returns to scale and that the level of efficiency can be represented by a multipliatively separable parameter, A. Then the function $S^*(\cdot)$ has the form:

$$S = AS(P, W)\, L. \tag{1}$$

Empirical implementation of equation (1) requires the assumption of a particular form for $S(\cdot)$. I will assume it is a weighted geometric average of the input and output prices:

$$S(P, W) = \prod_{i=1}^{m} P_i^{\alpha_i} \Big/ \prod_{i=1}^{n} W_i^{\beta_i}. \tag{2}$$

$S(\cdot)$ is linearly homogeneous which implies the restriction $\Sigma\alpha_i - \Sigma\beta_i = 1$. $\alpha_i = P_i Q_i/S$ and $\beta_i = W_i X_i/S$ are shares in surplus. Define Ricardian surplus per acre as $r = S/L$. Product and input shares in revenue and total cost can then be defined as $v_i = P_i Q_i/R$ and $u_i = W_i X_i/R$ and $u_L = S/R$ where u_L is land's share. Here $R = \Sigma P_i Q_i = \Sigma w_i X_i + vL$ is farm revenue or total cost. Consequently, $v_i = u_L \alpha_i$ and $u_i = u_L \beta_i$.

[1] This characteristic of Table 2 does not impair the finding of Table 1; namely, that rents in open field farms were about half of surplus, while rents in enclosed farms were close to surpluses.

[2] The requisite regularity assumptions and the resulting properties of the variable profit function are presented in Diewert (1974, pp. 133–7).

Suppose one observes the Ricardian surplus per acre of two farms, r_1 and r_2, whose technologies and behaviour satisfy the assumptions made here. By combining equations (1) and (2) and the definitions of the shares, one can infer relative efficient (A_2/A_1) by deflating r_2/r_1 by a geometric index of output and variable input prices:

$$\frac{r_2}{r_1}\frac{\prod_{i=1}^{n}\left(\frac{W_{2i}}{W_{1i}}\right)^{u_i/u_L}}{\prod_{i=1}^{m}\left(\frac{P_{2i}}{P_{1i}}\right)^{v_i/u_L}} = \frac{A_2}{A_1}. \tag{3}$$

In this paper, the efficiency, E, of the farm in case 2 will be defined to be a function of A_2/A_1:

$$E = \left(\frac{A_2}{A_1}\right)^{u_L}. \tag{4}$$

This definition is made since E equals a conventional index of real output divided by real input, as minor manipulation of equations (3) and (4) shows:

$$\frac{\frac{R_2}{R_1}\Big/\prod_{i=1}^{m}\left(\frac{P_{2i}}{P_{1i}}\right)^{v_i}}{\frac{R_2}{R_1}\Big/\left(\frac{r_2}{r_1}\right)^{u_L}\left[\prod_{i=1}^{n}\left(\frac{W_{2i}}{W_{1i}}\right)^{u_i}\right]} = E. \tag{5}$$

The left-hand side of equation (5) is an implicit index of real output divided by an implicit index of real input.

Equations (3) and (4) provide a basis for decomposing relative surplus per acre into relative efficiency and relative output–input price variations. For convenience, define the relative excess of output and input prices in case 2 to the base case 1 to be:

$$D = \frac{\prod_{i=1}^{m}\left(\frac{P_{2i}}{P_{1i}}\right)^{v_i}}{\prod_{i=1}^{n}\left(\frac{W_{2i}}{W_{1i}}\right)^{u_i}}. \tag{6}$$

Substituting equations (4) and (6) into equation (3) yields:

$$\frac{r_2}{r_1} = D^{(1/u_L)}E^{(1/u_L)}. \tag{7}$$

Equation (7) indicates how relative surplus per acre can be decomposed into price and efficiency effects.

The only limitation to the analysis developed thus far is that E can be computed only if $r_2/r_1 > 0$. Eighteen farms in the sample earned negative surpluses. Rather than discard them another efficiency index is defined.

$$E^* = \frac{\frac{R_2}{R_1}\Big/\prod_{i=1}^{m}\left(\frac{P_{2i}}{P_{1i}}\right)^{v_i}}{\left(\frac{L_2}{L_1}\right)^{u_L}\prod_{i=1}^{n}\left(\frac{X_{2i}}{X_{1i}}\right)^{u_i}}. \tag{8}$$

In this index the implicit index of inputs in the denominator of equation (5) is replaced with a direct index of inputs. A corresponding index of relative output to input prices can be defined as:

$$D^* = \frac{(r_2/r_1)^{u_L}}{E^*}. \qquad (9)$$

To decompose surplus per acre variations into price and efficiency components, price and efficiency indices were computed for every farm. The shares in revenue of all the inputs and outputs were computed for every farm and then averaged across all farms.[1] These average shares were used in all computations. For each

Table 3

Efficiency and Price Indices

	Efficiency I	Price I	Efficiency II	Price II
Open	1·12	1·11	1·22	1·05
Partially open	1·05	1·07	1·05	1·06
Enclosed	0·95	1·03	0·94	1·04

Notes

Efficiency I is E as computed by equations (3) and (4); Price I is D as computed by equation (6); Efficiency II is E^* as computed by equation (8); Price II is D^* as computed by equation (9).

farm, efficiency and price indices were computed according to equations (5), (6), (8) and (9). The base values (i.e. P_{1i}, W_{1i}, r_1, L_1, X_{1i}), in all of these calculations were the overall average prices, surplus per acre, and quantities of inputs.[2] Therefore, as the computed E, E^*, D, and D^* for a farm exceed or fall short of one, so its efficiency or the relative prices it faced exceed or fall short of this overall average.

Table 3 shows the mean values of E and D (labelled efficiency and price indices I) and E^* and D^* (labelled indices II) for the open, enclosed, and partially open farms. The variation of the average price indices is small compared to the variation in efficiency. This result is especially strong in the case of E^* and D^* but is also apparent in the case of E and D. When analogous comparisons are made among the farms in each of the three groups, the same pattern is observed; namely, that the variations in surplus per acre are associated with variations in E and E^* but not with D and D^*. It appears, therefore, that the von Thünen effect does not account for the variation in surplus per acre. When land is treated as a homogeneous input, the high surplus per acre of open field farms implies they were much more efficient than enclosed farms.

III. LAND CHARACTERISTICS, COMMONS AND EFFICIENCY COMPARISONS

That greater measured efficiency, however, might simply have been caused by the open field farms' having been situated on more fertile land. In this section that possibility is explored. This inquiry is much more difficult than the inquiry

[1] These computations were made before the exclusions mentioned in the footnote 1 on p. 938.

[2] To use these values as base values, one must assume that the average r and X_i are optimal values given the average P_i, W_i, and L.

of the last section since it is not possible to measure all of the characteristics that influence the capacity of land to generate surplus. The empirical work is restricted to exploring only some of the major determinants of land quality. Nevertheless, the results are reasonably strong: Depending on how one chooses to interpret them, anywhere from half to all of the differences in efficiency between open and enclosed farms is explained by variations in the quality of the land, as measured here.

Three characteristics of land are analysed: predominant soil type (sand, loam, clay or moor), average rainfall, and degree-days of heat. In addition common rights can be incorporated into the model systematically by treating them as a characteristic of the arable and grass of the farm. Common rights are difficult to measure. A farmer acquired such rights by occupying land in the fields of a village possessing a common. In some villages there was no limitation on the number of animals a farmer could pasture on the common, but in most villages the common was stinted, and a farmer's stint, i.e. the number and type of animals he could pasture on the common depended on the acreage he held in the fields. The appropriate measure of a farm's common rights would be its stint, which might be infinite. The stint rights of the farms in this data set are not known. A variety of proxies for their rights were explored but only one gave plausible results in the statistical estimations. That measure of stint rights took on a value of zero if a farm was located in a village without a common but equalled the number of sheep the farm possessed if the farm was located in a village with a common. Since the farms located near very large areas of common waste (like the Yorkshire wolds or the Wiltshire downs) used the commons for grazing sheep and kept large flocks, it is not surprising that this proxy for stint rights works well.

As a first experiment to see whether land characteristics influence efficiency, the equations shown in Table 4 were estimated. In regressions 1–3, E^* was the dependent variable and the sample consisted of all 231 farms. In equation (1) E^* is regressed on a constant and dummy variables for enclosed and partially open farms. (The corresponding dummy variable for open farms is excluded.) The coefficient of the dummy variable for enclosed farms is negative and strongly significant. In equation (3) variables representing the land characteristics are also included in the regression. Adding these variables substantially reduces the absolute magnitude of the coefficient of the dummy for enclosed farms and makes it insignificantly different from zero. The coefficient of the partially open farm dummy also becomes inconsequentially different from zero. Taking account of land characteristics, therefore, eliminates the differences in efficiency among open, enclosed and partially open farms.[1]

Similar but more modest results are shown in equations (4–6). In those equations the dependent variable is E and the sample consists of the 213 farms with positive surpluses. Equation (5) shows that the mean value for E is signifi-

[1] It will be noted that the R^2 values for these regressions and the others reported in this paper are not notably high. Two factors (other than the specifications) might amount for this. First, there is some error in the measurement of the variables. Second, not all relevant variables are included as independent variables. In particular, there are no variables that capture the farmer's competence. Farmers must have varied enormously in this regard, and that variation must have accounted for much of the variation in farm efficiency.

Table 4

Efficiency on Characteristics

(*t ratios in parentheses*)

Regression ...	1	2	3
Dependent variable ...	*E**	*E**	*E**
Constant	1·217	0·326	0·434
	(17·692)	(1·429)	(1·707)
DE	−0·278	—	−0·114
	(−3·735)		(−1·362)
DP	−0·163	—	−0·018
	(−1·878)		(−0·197)
DL	—	−0.033	−0·033
		(−0·604)	(−0·593)
DC	—	0·050	0·026
		(0·682)	(0·324)
DM	—	0·037	−0·006
		(0·370)	(−0·057)
R	—	0·006	0·007
		(1·472)	(1·893)
H	—	0·019	0·016
		(2·701)	(2·226)
T	—	0·176	0·157
		(6·790)	(5·655)
R^2	0·064	0·240	0·252
N	231	231	231
Regression ...	4	5	6
Dependent variable ...	*E*	*E*	*E*
Constant	1·123	0·319	0·431
	(25·502)	(2·043)	(2·499)
DE	−0·175	—	−0·112
	(−3·651)		(−2·008)
DP	−0·073	—	−0·017
	(−1·290)		(−0.289)
DL	—	−0·045	−0·044
		(−1·191)	(−1·170)
DC	—	−0·010	−0·035
		(−0·203)	(−0·664)
DM	—	0·866	0·043
		(1·301)	(0·642)
R	—	0·006	0·008
		(2·465)	(3·076)
H	—	0·021	0·018
		(4·390)	(3·676)
T	—	0·069	0·051
		(3·891)	(2·698)
R^2	0·075	0·174	0·204
N	213	213	213

Variables

*E** efficiency index II in Table 3 and defined by equation (8).
E efficiency index I in Table 3 and defined by equations (3) and (4).
DE dummy variable with a value of one for enclosed farms.
DP dummy variable with a value of one for partially open farms.
DL dummy variable with a value of one for loam soil.
DC dummy variable with a value of one for clay soil.
DM dummy variable with a value of one for moor soil.
R inches per year of rain.
H hundreds of degree days of heat per year.
T common rights.

See the Appendix for the sources and detailed definitions of variables.

cantly less for enclosed farms than for open farms. In equation (6), when the variables representing land characteristics are added, the coefficient of the enclosed dummy is closer to zero than it was in equation (4) but is still significantly different from zero.

The regressions on Table 4 particularly those involving E^*, lend support to the view that it is the superior quality of their land and their extensive common rights which account for the high surplus per acre generated by open field farms. A sounder test, however, can be developed by incorporating the characteristics of land into the model of the farm developed in the last section. Rather than assume that the land input of a farm can be measured by the sum of its arable and grass, it ought to be measured as a linearly homogeneous aggregate of the characteristics of the land, including the appurtenant common rights. Equation (1), the function describing the farm's behaviour, is then modified by replacing L with the aggregate $L = F(\mathbf{C})$, where $\mathbf{C}$ is the vector of land characteristics:

$$S = AS(P, W)\, F(\mathbf{C}). \tag{10}$$

In the empirical work, the characteristics of land are taken to be RL, the volume of rain falling on the farm in inch-acres, HL, the useful heat the farm receives in hundreds of degree-days, T, the common right, and L, the area of the farm. $F(\mathbf{C})$ was taken to be linear in these variables.

$$F(\mathbf{C}) = B_1 RL + B_2 HL + B_3 T + B_4 L \tag{11}$$

subject to the restriction $\Sigma_{i=1}^{4} B_i = 1$ which imposes linear homogeneity. The coefficients B_i are the marginal valuations of the characteristics. Analogously with equation (3) and (4), the relative efficiency of two farms can be measured as:

$$\left[\frac{S_2/S_1}{F(\mathbf{C}_2)/F(\mathbf{C}_1)}\right]^{u_L} \frac{\Pi\left(\frac{W_{2i}}{W_{1i}}\right)^{u_i}}{\Pi\left(\frac{P_{2i}}{P_{1i}}\right)^{v_i}} = \left(\frac{A_2}{A_1}\right)^{u_L} = E_c. \tag{12}$$

Equation (12) suggests an obvious test of the hypothesis that it is the superior quality of the land upon which open field farms were situated and their more extensive common rights which was responsible for their higher measured efficiency. If E_c is computed for every farm, its average value for open, enclosed, and partially open farms should be equal if the hypothesis is correct.

In order to carry out the test, it is necessary to estimate the coefficients of equation (11) so that E_c can be computed. The coefficients were obtained by estimating the following equation, which was suggested by equations (10) and (11):

$$\frac{S/L}{D^{1/u_L}} = B_1 R + B_2 H + B_3 (T/L) + B_4. \tag{13}$$

The restriction $\Sigma_{i=1}^{4} B_i = 1$ was imposed to guarantee linear homogenity in the characteristics. The result was:

$$\begin{aligned} \frac{S/L}{D^{1/u_L}} &= 0{\cdot}00384\, R + 0{\cdot}0201\, H + 0{\cdot}319\, (T/L) + 0{\cdot}657. \\ &\quad\ (0{\cdot}644) \qquad\ (2{\cdot}337) \qquad\ (4{\cdot}475) \qquad\quad (8{\cdot}949) \end{aligned} \tag{14}$$

$R^2 = 0{\cdot}1187$ t ratios in parentheses.

There is little basis for forming alternative estimates of the shadow prices of the environmental variables in equation (14). One can, however, construct alternative estimates of the value of T/L (common rights per acre of land in the fields) and compare those alternative estimates with the coefficient of T/L. The coefficient of T/L in equation (14) indicates that a farmer facing average input and output prices (so $D = 1$), would be willing to pay about 6 shillings (£0·3188) more in rent for an acre of land if it carried with it the right to pasture one sheep (the measure in which common rights have been measured) on a common. An alternative estimate of the value of a common right to a farmer would be the value of the products of a sheep minus the non-land costs incurred in obtaining those products. Most farmers sold their flocks after a year and bought new sheep to replace them. Young frequently reports the 'profit' of sheep, i.e. the value of a sheep's products less its purchase price. For sheep kept on commons, the average 'profit' was 5–8 shillings per sheep. From this, one ought also to subtract the shepherd's wage per sheep, but that was a very small number[1] that can be safely ignored. Hence, this alternative estimate of the shadow price of commons, 5–8 shillings per sheep, is strikingly consistent with the shadow price implied by equation (14). This consistency is important confirmation of the equation.

The positive and significant shadow price of common rights conveys another important lesson about eighteenth century agriculture. It is often loosely argued that commons were common property resources and overgrazed to the extent that all rent was dissipated. If that argument were true, no farmer would be willing to pay a higher rent for arable simply by virtue of any common rights appurtenant to it. Since farmers were willing to pay higher rents for such land, the value of their commons had not been dissipated.

The coefficients in equation (14) were used to compute E_c defined by equation (12). Table 5 shows the results obtained when E, E^*, and E_c were regressed on a constant and dummy variables identifying enclosed and partially open farms. In all three regressions, the sample consisted of the 213 farms showing positive surpluses, and, to facilitate comparison, E^* and E_c were normalised, so that their mean values for open field farms equalled the mean value of E. The regressions involving E and E^* both show enclosed farms significantly less 'efficient' than open field farms. However, in the regression of E_c as the dependent variable, the coefficient of the enclosure dummy is much closer to zero and is no longer significantly different from it. Thus, when land is correctly measured, i.e. as an economically well defined index of its characteristics rather than simply by its spatial dimensions, the systematic difference in efficiency between open and enclosed farms disappears. The result is a consequence of the fact that open field farms were located on drier but warmer land than enclosed farms. The most prominent cause of the greater 'efficiency' of open field farms, however, was their more extensive common rights.

The finding of no difference in efficiency among the three classes of farms gains plausibility when one examines the details of farm management. Table 6 presents average values for some important characteristics of the farms. In all cases the

[1] For instance, the calculation of Young (1771, vol. III, p. 330) indicate that the shepherd's wage cost per sheep was 0·2 shillings.

average sizes were well above minimum efficient size. The average size of open and enclosed farms were quite similar (247 and 274 acres, respectively) while partially open farms were considerably larger (566 acres). These sizes, in fact, under-represent the quantities of land utilised by the farms, for common rights

Table 5

Efficiency Index Incorporating Characteristics

Regression no. ...	1	2	3
Dependent variable ...	E	E^*	E_c
Constant	1·123	1·123 (18·469)	1·123 (13·502)
DE	−0·175 (−3·65)	−0·233 (−3·525)	−0·093 (−1·135)
DP	−0·076 (−0·59)	−0·112 (−1·446)	0·135 (1·267)
R^2	0·075	0·066	0·047
N	213	213	213

Variables: E_c defined by equation (12). All other variables defined in Table 4.

Table 6

Land Use Patterns and Crop Yields

	Open	Enclosed	Partially open
	Major division (acres)		
Grass	70·148	143·201	275·556
Arable	177·148	130·956	290·111
	Distribution of the arable (%)		
Wheat	22·768	18·788	22·061
Barley	17·144	16·997	20·950
Oats	9·471	16·593	9·873
Peas	10·976	5·754	8·633
Beans	5·917	2·699	7·032
Turnips	8·488	11·964	11·214
Clover	4·286	11·507	6·281
Fallow	20·950	15·698	13·956
	Crop yields (bushels per acre)		
Wheat	24·519	22·470	25·756
Barley	36·185	30·723*	33·511
Oats	40·667	36·371*	47·489
Peas	20·815	21·440	20·800
Beans	30·467	27·947	27·107

* The difference between this mean and the corresponding open field mean is statistically significant at the 5% level.

are not included. All classes of farms had a high proportion of their land under grass. The proportion is smallest in the case of open field farms, but this disproportion is at least partly due to the omission of common pasture.

Arable husbandry was similar on the three sorts of farms. The enclosed farms had gone a bit further in eliminating fallows and introducing clover and turnips than had the open farms, but the open farms were certainly not static. Their rotations were far from the early modern practice of a year of wheat or barley followed by a year of peas or beans, and then a year fallow. The partially open farms, likewise, had modernised to a considerable degree. Moreover, there was little difference in the crop yields among the three types of farms. Mean yields on the open farms, in fact, were slightly higher than on the enclosed farms. However, it was only in the cases of barley and oats that the differences were statistically significant. Overall, the differences in arable husbandry were not dramatic.

IV. CONCLUSION

The data collected by Arthur Young in his tours of England support two conclusions. First, only half of the surplus generated by open field farms accrued to the landlord as rent and to the church and state as tithes and rates. Hence, introducing free competition into the farm lease market would approximately double rents and substantially lower farmer's incomes. Second, enclosure did not raise efficiency. Indeed, the first comparisons undertaken showed enclosed farms to be less efficient than open field farms. However, when differences in the characteristics of the land (treating common rights as one of those characteristics) were incorporated into the comparison it was possible to accept the statistical hypothesis that open and enclosed farms were equally efficient. The data on crop yields and land use patterns buttress this result. The overall conclusion to which these findings point is that the major economic consequence of the enclosure of open field arable in the eighteenth century was to redistribute the existing agricultural income, not to create additional income by increasing efficiency. The major limitation to this conclusion is that the data pertain to farms located in places where the optimal land use strategy involved a heavy commitment to arable farming and where the soil was light enough to permit the cultivation of turnips. In other environments, open field farming may not have been as successful *vis-à-vis* enclosed farming.

The finding that enclosure did not raise efficiency contradicts the influential work of early twentieth century historians like Ernle (1961) who contended that enclosure was a prerequisite to the adoption of advanced methods. Although that view became the conventional wisdom, it has been seriously undermined by recent agricultural historians who have shown that open field farmers did indeed adopt modern practices (Havinden, 1961; Kerridge, 1969; Yelling 1977). The conclusions of this study extend those findings and, in turn, are made more plausible by them.

The finding that open and enclosed farms were equally efficient is interesting in the light of much recent work on the efficiency of agriculture in developing countries. At one time, it was widely believed that small scale peasant farming was inefficient. Much recent research, however, has shown that those farmers are indeed as efficient as large capitalist farmers (e.g. Yotopoulos and Nugent (1976, pp. 87–106)). While the parallels with eighteenth century England are loose, an analogous rehabilitation of the once maligned open field farmer is underway. To carry the parallel further, the enclosure movement itself might be regarded as the first state sponsored land reform. Like so many since, it was justified with efficiency arguments while its main effect (according to the data analysed here) was to redistribute income to already rich landowners.

The most difficult finding of this paper to account for is the renting of open field land at less than its value. Such a pattern would be inconsistent with a competitive market for tenancies in which rents were frequently renegotiated. The institutions of the open fields, however, seem to have departed from these arrangements in two ways. First, some land may have been let for long terms at low customary rents. It was indeed the case that virtually every enclosure act contained a clause cancelling existing leases and thus allowing renegotiation at competitive rents. Second, bilateral bargaining between the farmers as a group and the landlords may have been important in setting open field rents. Such bargaining would emerge when the adoption of new cropping patterns was discussed. In the late eighteenth century, it was the tenant farmers (not the landowners) who chose the cropping pattern (Yelling, 1977, p. 147). The farmers would have had no incentive to modernise unless they received some of the benefits. Since enclosure, which broke village control over cropping, was costly, the landlords would find it advantageous to concede some benefit to the farmers in the form of low rents. Unfortunately, Young was silent on the tenancy arrangements of the villages he visited so these conjectures cannot be explored with his data.

University of British Columbia, Vancouver

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APPENDIX

The purpose of this Appendix is to describe the main principles and procedures used in putting together the data set. Allen (1979) is a more complete explanation and is available on request.

In compiling the data, it was necessary to determine the price and quantity of every input and output for every farm. Farm revenues consisted of the sales of arable crops and livestock products. Farm costs consisted of the cost of seed, livestock, labour, and implements. With some minor exceptions discussed in Allen (1979), these magnitudes were estimated as follows:

(1) *Crops and Seed*

Young indicated the acreage of each farm devoted to wheat, barley, oats, peas, beans, clover, turnips, and fallow. Following Marshall (1796, vol. II, p. 140) and subject to some internal checks, it was presumed that all farms were self sufficient in forage so crop revenues equalled the sale of wheat, barley, oats, peas, and beans. Production and seed requirements of these crops were estimated by multiplying the farm acreage by the average yields and sowing rates for the crops in the village where the farm was located. The prices of the crops were taken to be the average 1771 London *Gazette* prices in the principal market towns of the county in which the farm was located. Peas and beans were presumed to sell at the same price. The prices of seed were taken to be the same as the corresponding crop prices except that the seed prices were increased by 5% to include the foregone interest on the investment in seed.

(2) *Livestock*

For each farm Young recorded the number of dairy cows, sheep, 'fatting beasts', young cows, and draught animals. The first four kinds generated revenue. Dairy revenue was computed as the number of cows multiplied by the 'average value of the products of a cow' for the village where the farm was located. Dairy cows were capital goods and were assumed to be worth £5. Annual rental prices were computed on the basis of a 5% interest rate and a 15% depreciation rate.

Sheep, fatting beasts, and young cows were treated as though they were bought at the beginning of a year and sold (along with wool and lambs in the case of sheep) at the end of the year. They were presumed to cost 12 shillings, £5, and £3 respectively. In the case of sheep, revenues were taken to be 12 shillings plus the 'profit of a sheep' which Young reported for each village; fatting beast revenue equalled £5 plus the analogous profit figure (again reported for the village); young cows were presumed to sell for £5.

The prices of the various sorts of livestock products were taken to be the prices ruling in the village where the farm was located for cheese (for dairy products), mutton (for sheep products), and beef (for fatting beast and young cow products).

Draught animals were assumed to be worth £10 and interest and depreciation on them was computed at 5 and 15%, respectively. For horses, the cost of oats and shoeing was computed by subtracting the summer joist (assumed to be accounted for elsewhere) from the annual cost of keeping a horse. These values were reported at the village level and imputed to all the farms in the village.

(3) *Implements*

Implements were treated as capital goods. Since Young rarely recorded details of their quantities, the numerous farm descriptions in Young (1770) were used to estimate for each farm the number of wagons, broad-wheeled wagons, carts, three-wheel carts, harrows, rollers, and sacks as well as the value of dairy furniture, harness, and miscellaneous equipment.

Fortunately Young recorded for each village the purchase prices of these implements. Interest and depreciation were figured at 20%.

(4) *Labour*

Young recorded the number of servants, dairy maids, boys, and labourers employed. The first three kinds of labour were hired on annual contract and provided with room and board in addition to a money payment. Young records the money payment for each village. Room and board was taken to be £9 per year for servants, £6. 10*s*. for boys, and £5 for maids, following Young (1967), vol. IV, p. 356. The wage rate for labourers was taken as fifty-two multiplied by the average weekly wage reported for each village by Young.

It was necessary to estimate the quantity and opportunity cost of family labour. Farms run by gentlemen were presumed to use no family labour (Young 1770, vol. I, pp. 246–80). Other farm families were presumed to supply one first class servant, one maid, and one boy. This labour was valued at the local money wage plus the cost of room and board.

It was also necessary to estimate harvest labour. Following Young (1771, vol. IV, p. 460), the quantity of this labour was estimated at 25% of the number of labourers employed. This labour was valued at the same wage rate as the labourers.

(5) *Tithes and Rates*

Local rates were estimated by multiplying each farm's rent (which Young reported) by the village rate. Where tithes were compounded, the composition of the village was used to compute the tithe liability. Average compositions for each county were worked out and used to estimate tithe liabilities for farms where tithes were collected in kind.

(6) *Environmental Variables*

Rainfall was taken to be average annual rainfall in inches for the years 1916–50 as plotted on Ordnance Survey (1967). Soil type was determined from Bickmore and Shaw (1963, p. 40). Degree-days (in hundreds of degrees Fahrenheit) were obtained from Gregory (1954, p. 65).

A further line of research pertaining to the data must be noted. Young did not always indicate whether a village was open or enclosed. It was consequently necessary to examine printed and archival sources in order to classify the farms. Large scale eighteenth century county maps, many of which were drafted around 1770, were the most helpful printed sources, for they usually indicated, by varying the symbol identifying a road, whether it was passing through open or enclosed fields. In addition, archival material was examined for villages in which most of the farms were located. Twenty-seven county record offices or comparable archives were visited. The principal object was to examine manuscript maps, made about 1770, to ascertain the predominant field patterns. The property descriptions in glebe terriers, estate surveys, mortgages, deeds, conveyances, and leases were occasionally also useful.

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