A Non-Neo Malthusian Model of English Land Value, Wages, and Grain Yield Before the Black Death

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Postan has put forward what might be called a neo-Malthusian model of the English economy prior to the Black Death in 1348. In his model declining grain yields play a key role by helping to explain why the produce of the land ceased to be adequate to feed the medieval population. Postan [1] maintains that "the most direct evidence available to us, that of demesne crops, bears witness to yields declining in the thirteenth and the early fourteenth centuries, and to the underlying presumption of the deteriorating quality of arable lands." He goes on to explain that the "cure" for agricultural insufficiency "took the form of recurrent famines, high and rising mortalities, and perhaps also of low and declining marriage and birth rates".[2] But the "true turning point," Postan [3] argues, "occurred at least two decades before the outbreak of the pestilence, or perhaps even earlier," In support of his position he points out that even prior to 1348 "the values of land were falling (while) the values of men — their wages — were rising".[4]

The present paper attempts to account for declining grain yields and rising wages relative to land values within the framework of a simple general equilibrium model with two productive sectors, wool and grain, and two productive factors, labour and land. Unlike Postan we make no reference to relative overpopulation or to decaying arable land and none is required. Further, the rise in the relative price of labour did not occur *after* declining grain yields but at

[1] 1972, p. 63.
[2] 1972, p. 38.
[3] 1972, p. 38.
[4] 1972, p. 36.

the same time. It is suggested that export taxes on wool, and the land-intensive output, caused an expansion of the labour-intensive, output grain. Consequently, the relative price of labour rose while average grain yields fell, due to a rise in the land intensity of production. Wherever possible empirical evidence is used to quantify and test the key assumptions and implications of the theoretical analysis.

I

During the XIIth and XIIIth centuries England developed a large and vigorous wool trade, primarily with the cloth producers in Flanders. A long era of free trade ended in 1275 when England imposed a tax of 6.67s. on the export of each sack (364 pounds) of shorn wool.[5] The impact of this "Ancient Custom" could not have been regionally uniform since, owing to quality differences and other factors, prices paid by export merchants to English wool growers differed sharply from one area to another. In 1275 the range of average prices among seven growing areas[6] was 1.63s., or 39 percent of the overall average price. The tax represented 6.7 percent of the average price received by the Winchester manors in Hampshire and Wiltshire but dropped to 5.2 percent for the wool of the Cotswolds. In Somerset (only one observation) the fraction jumped to its maximum 1275 value of 7.9 percent.

The potential impact of the tax on the price of cloth is more difficult to gauge. Fryde[7] considered data on shipping and storage charges for the period 1336-43 and reached the conclusion that about 27s. per sack represented a reasonable though probably somewhat inflated estimate of the charges. The Ancient Custom represents 4.9 percent of the overall average wool price in 1275 (107.9s.) plus the shipping-storage estimate (27s.). In 1434 and 1442 at Leuven English wool accounted for 62.5 percent and 55.1 percent, respectively, of the average variable cost of producing fine black cloths.[8] De Roover[9] presents Florentine data in which wool of unspecified origin represented around 40 percent of the total cost of producing cloth of unspecified quality. Surely 50 percent represents a conservative estimate of the share of average total cost represented by English wool. This would mean that the Ancient Custom had the potential to raise average total cost by at least 2.5 percent.

The "New Custom" of 1303-11 and 1322 discriminated against foreign exporters of English wool. While the denizen continued to pay 6.67 s. the alien had to pay 10 s.[10] In 1333 denizens had to pay an additional 6.67 s.

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[5] Carus-Wilson and Coleman, 1963, p. 12.

[6] Lloyd, 1973.

[7] 1964, pp. 13-15.

[8] Munro, 1977, Table 13.2.

[9] 1968, fn. 1, p. 268.

[10] Bolton, 1980, p. 194; Carus-Wilson and Coleman, 1963, p. 12.

and aliens an additional 10 s. per sack. Beginning in 1336, however, the rates rocketed: denizen exporters paid 40 s. per sack while the alien was charged 60 s. From 1340-49 the average tax for denizens was 47.3 s. while for aliens it amounted to 55.7 s.[11] Taking 1345 for purposes of illustration, the denizen tax represented 61.6 percent of the average price received by growers in Lloyd's [12] lowest price area while it amounted to a still sizeable 38.9 percent for the highest price area. Turning again to the costs of cloth production, the denizen tax of 47.3 s. amounted to 40 percent of the 1345 overall average wool price (94.4 s.) plus the shipping-storage charge (27 s.). Thus the tax had the potential to raise the cost of producing cloth by a minimum of 20 percent as compared to 2.5 percent in 1275.[13]

The economic impact of an excise or specific tax is one of the traditional questions of comparative statistics. As a first approximation, the wool industry is assumed to be competitive with the demand and supply curves shown in figure 1. D_0 is the short-run demand curve for English wool on the part of the cloth producers in Flanders. (To facilitate the analysis the domestic demand for wool is ignored.) To obtain the short-run supply curve of the wool growers it is necessary to sum their short-run marginal cost curves horizontally beginning at minimum average variable cost. The result is S_0. Thus, prior to the tax, the equilibrium price is P_0 while the equilibrium quantity of wool produced and exported is W_0. When the export tax is imposed the marginal cost curves of the wool producers can be understood as shifting up vertically by the amount of the tax. This, in turn, causes the short-run supply curve of the industry to shift upward by the amount of the tax to S_1. Consequently, the equilibrium price rises to P_1 and the equilibrium quantity declines to W_1.

Notice that the new price paid by the cloth manufacturers (that is, P_1), is greater than the old price, P_0. Thus the manufacturers pay part of the tax.

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[11] CARUS-WILSON and COLEMAN, 1963, p. 194; POWER, 1941, pp. 54, 82; LLOYD, 1973, p. 19; MUNRO, 1977, Table 13.1.

[12] 1973.

[13] Obviously the high export tax encouraged wool smuggling. However, CARUS-WILSON and COLEMAN (1963, pp. 22, 29) point out that: "The facilities of a well-appointed port were required to handle the customary sarplar (which might contain some $2\frac{1}{2}$ sacks of wool). To load any worthwhile amount in out-of-the-way creeks not equipped with cranes would be tiresome, to say the least, while cartage and shipment of any significant quantity... could scarcely escape detection if regularly practised." Proceedings of the Exchequer court "bring to light a smuggling trade averaging only 0.15 percent of the legitimate trade actually recorded in the customs accounts. If, to allow for smuggling that went undetected, we were even to magnify fiftyfold the cases brought to court, and the quantities of smuggled wool there disclosed, our recorded exports in the customs accounts would still amount to over 90 percent of the total trade...".

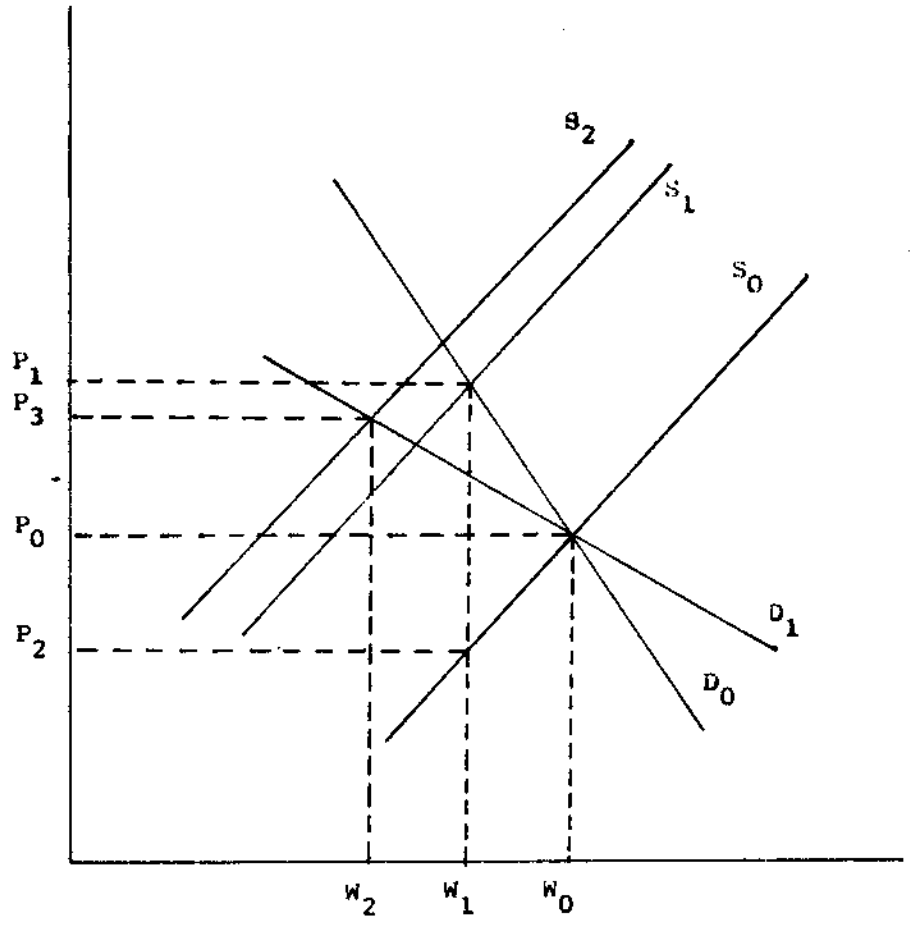

FIGURE 1

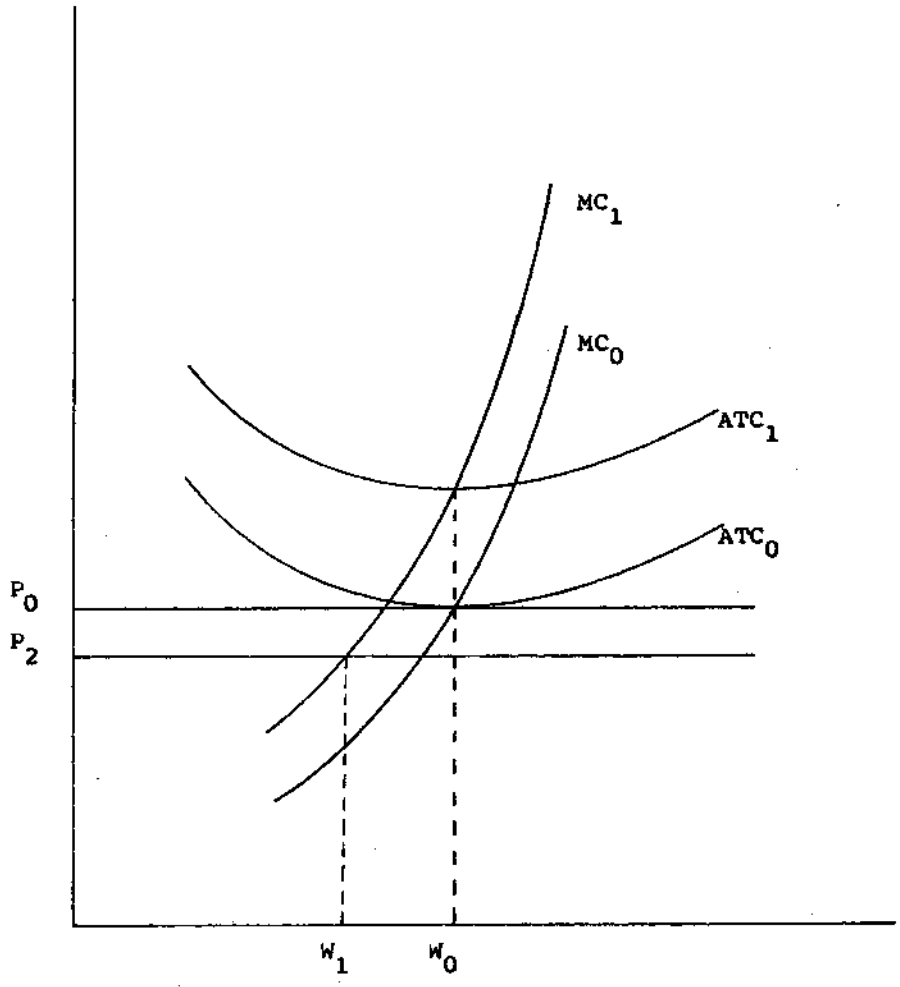

FIGURE 2

However, the new price, net of tax (that is, P_2), is less than P_0. Thus the wool producers are getting less than they did before, net of taxes, and so they, too, pay part of the tax. (The proportions in which sellers and buyers divide the tax depends on the relative elasticities of demand and supply.) More importantly for present purposes, the effect which the tax will have on wool output depends on the relative elasticities of demand and supply. The more inelastic the demand and supply curves, the smaller will be the fall in output caused by any given tax.

In order to understand what happens next we must examine the circumstances of the marginal or high-cost wool producers. It should be noted that a firm may have relatively high costs *either* because the entrepreneur's direct production costs are high or because his alternative earnings, say in grain growing, are high. The initial equilibrium of a marginal wool producer is shown in figure 2. The firm is earning a normal profit at the pretax price P_0 and producing w_0. The imposition of the tax raises the firm's average total cost and marginal cost curves by the amount of the tax. The post-tax curves are ATC_1 and MC_1. At the new price net of tax, that is P_2 (see figure 1), the marginal firm is earning short-run economic losses. The presence of losses in the short-run sets in motion forces that contribute to the new long-run equilibrium. Given time, the marginal producers leave the wool industry. The reduction in the number of firms shifts the market supply curve in figure 1 upward and leftward to S_2.

Adjustments take place on the demand side as well. Cloth producers adopt somewhat less wool-intensive processes of production; consumers of cloth switch to substitutes. The result is shown in figure 1 by the more elastic long-run demand curve D_1. The longrun post-tax equilibrium is given by the intersection of D_1 and S_2. Notice that the equilibrium quantity decreases to W_2, that is, by more than the short-run decrease.

Beginning in 1336-37, however, the wool trade ceased to be competitive.[14] Edward III revived and utilized export staples in order to extract a monopolistic price from foreign cloth producers.[15] In addition, during 1337-43, several attempts were made to exploit English wool growers and non-staple (or non-syndicate) merchants by fixing buying prices below current market levels.[16] The most flagrant scheme was initiated in the summer of 1337 when, according to Barnes,[17] " the King arrogated to himself the sole right of buying wool in the kingdom and of exporting it out of the kingdom hoping apparently to use his monopoly to force up prices." Another scheme involved the imposition on a national basis of taxes that had to be paid not in cash

[14] FRYDE, 1952, p. 9.
[15] UNWIN, 1918, pp. 187-90. See BOLTON, 1980, pp. 193-5 on the wool staple.
[16] BARNES, 1918, pp. 145-48; LLOYD, 1973, p. 10; UNWIN, 1918, p. 190.
[17] 1918, p. 144.

but in wool. Those who refused to sell their wool to the King or to ordinary citizens who needed it to pay their taxes might find it forcibly sold at the fixed price or even confiscated.[18] In March 1339 private merchants were once again allowed, after paying the heavy export tax, to ship their wool to the staple at Antwerp.[19] But in the interests of the Wool Company, private wool shipments were again forbidden in May 1341 and on occasion during 1343-49.[20] Lloyd[21] notes that the wool trade was in a "state of crisis" in the winter-spring of 1342-43. The prohibition of exports was lifted in 1344 and reimposed in 1347.[22]

Figure 3 visualizes the impact of Edward's policies in terms of a model wherein the staplers are monopsonists in the domestic market for wool and monopolists in the Flanders wool market. Once again S_0 is the supply curve of wool, D_0 is the demand curve, and W_c is the equilibrium price under competition. *MWC* is the marginal wool cost curve, that is, the increase in the monopsonists total cost attributable to the purchase of an additional sack of wool. (Note that the positively sloped supply curve implies that all sacks sell at a higher price when one more sack is purchased.) *MWR* is the marginal wool revenue curve, that is, the increase in the total revenue of the monopolist attributable to the sale of an additional sack of wool. (Note that the negatively sloped demand curve implies that all sacks sell at a lower price when one more sack is sold.) Profit maximization is achieved by equating *MWR* and *MWC*. The equilibrium price paid by cloth manufacturers rises to P_m, the price paid to growers falls to P^*, and the equilibrium quantity drops to W_m. Note finally that the monopoly model can be modified by adding the export tax to the marginal cost curve.

The selling-price raising, buying-price lowering prowess of the staplers is demonstrated in the accounts of important merchants who, from 1336-44, acted as royal agents for the transport and sale of wool. In six transactions for which complete data are available, the Dordrecht sale price fixed by a committee of merchants exceeded the purchase price in England plus shipping-storage charges by percentages of 27.9, 37.3, 37.9, 40.3, 52.3, and 75.[23]

Export taxes operated to discourage wool exports generally but the greatest impact would have been felt by lower quality, cheaper grades. The latter point is easily illustrated. In 1345 the ratio of the price paid to English growers in Lloyd's[24] highest price area plus a transport-storage allowance of 27 s.

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[18] LLOYD, 1977, pp. 152, 163.

[19] BARNES, 1918, p. 152. Apparently, the non-syndicate merchants also had to pay to the staplers a fee of 13d. per sarplar of wool (FRYDE, 1952, p. 14).

[20] BARNES, 1918, p. 165; FRYDE and FRYDE, 1963, p. 461.

[21] 1977, p. 193.

[22] BARNES, 1918, pp. 168, 170.

[23] Calculated from data in FRYDE, 1964, Appendix.

[24] 1973.

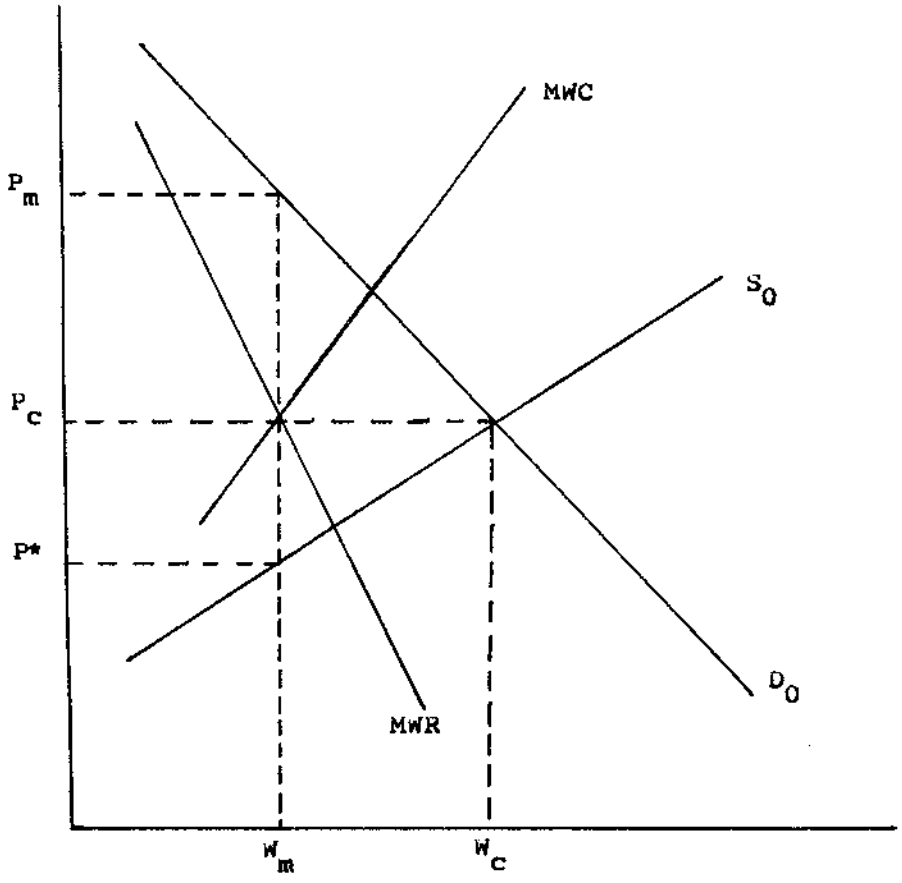

FIGURE 3

to the price paid to growers in the lowest price area plus 27 s., was 1.41. That is, a sack of high quality wool cost the cloth manufacturer in Flanders 41 percent more than a sack of low quality wool. But when 47.3 s., the average denizen export tax for 1340-49, is added to numerator and denominator of the price ratio it declines to 1.28. For cloth manufacturers this represents a 9.2 percent decline in the relative price of higher quality wool.

Indeed Munro [25] tells us that the important late XIIIth century export trade in cheap (coarse and light) cloths to the Mediterranean area virtually disappeared during the first half of the XIVth century. The Flemish manufacturers were displaced by southern Europeans utilizing Italian or Spanish wool. The comparative advantage of Flanders came to reside in the transformation of high quality wool into luxury cloth. Nevertheless, a rising portion of this wool came not from England but from Spain. Shortly before 1300 North African merino sheep were crossbred with native strains, arable land was grassed down to make sheep-runs or allowed to fall down to rough grazings, and the Spanish contribution to the international supply of high quality wool began to rise.[26] Numbers are unavailable but it is quite possible that by the middle of the XIVth century Spanish wool was playing a significant role in both Florentine and Flemish cloth production.

The combination of economic forces discussed above are reflected in a sizeable decline in English wool exports. From the first year for which data is available to the last year before the sharp increase in the export tax, that is from 1279-80 to 1334-35, exports averaged 27,276 sacks per year. But during the next eight years, 1335-36 to 1342-43, the annual average fell 27.3 percent to 19,839 sacks per year.[27] A more revealing comparison is that between 1327-28 to 1334-35 and 1335-36 to 1342-43; during the former eight year period wool exports averaged 31,072 sacks, or 36.1 percent more than in the latter eight years.

3000 sacks per year represents a quite generous estimate of the raw wool equivalent of increased English cloth production for export and to replace imported cloth.[28] However, even when this inflated total is added to the

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[25] 1972, p. 2; 1977, pp. 23-31.

[26] JACKSON, 1972; MISKIMIN, 1969, pp. 62-4; C.T. SMITH, 1967, p. 249; TATE, 1973, pp. 88-9.

[27] As a result of the farming of the customs in 1343-44, export data are unavailable until after the Black Death in 1350-51.

[28] Imports of cloth into England by aliens averaged some 12,000 cloths per year in 1303-11 and only 2000 in the late 1330 s (CARUS-WILSON, 1954, n. 2, p. 242). Assuming that a sack of wool was sufficient to produce 4.5 cloths (CARUS-WILSON and COLEMAN, 1963, pp. 15-16), the raw wool equivalent of the 10,000 cloth decline in imports is 2222 sacks. English cloth exports were negligible before the Black Death. A check on the above estimate is provided by the ulnage accounts for 1354-55 which

export total for 1335-36 to 1343-44, *the decline in the market production of wool, from 31,072 to 22,839 sacks, is still 26.5 percent.*

The decline in wool production is well illustrated by what reportedly happened on the manors of Canterbury Cathedral Priory. In 1332 these manors were producing at a rate of some 68 sacks of wool per year,[29] but according to R.A.L. Smith,[30] " the number of stock markedly declined before the middle of the fourteenth century." Smith cites the example of Lyden manor in East Kent whose sheep flock declined from 722 in 1331 to 509 in 1345, a decline of 29.5 percent. Smith [31] adds that " the drop in the output of Canterbury wool production faithfully reflected the general decline in sheepfarming which took place in England at this period."

II

The adjustments in the English economy required to return it to equilibrium after the imposition of export taxes in 1275 and 1336 can be visualized by means of a simple general equilibrium model [32] with two factors of production, labour (M) and land (S), and two products, wool (W) and grain (G). It is assumed that:

(1) The production functions for both outputs, W and G, are homogeneous of degree one.

(2) Factor prices adjust to maintain the employment of given overall supplies of both S and M.[33] [34]

(3) For any set of factor prices, the production of W is more land-intensive than the production of G, that is, for any given ratio of factor prices, the ratio of land (S) to labour (M) is greater in wool (W) than in grain (G).

Assumption (3) at least is unquestionably realistic.[35] Some quantitative

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show that 10,665 cloths were produced for domestic sale and for export (GRAY, 1924, p. 34). In this case the raw wool equivalent is 2370 sacks.

[29] In 1332 the Canterbury Cathedral Priory possessed a total of 13,730 sheep (R.A.L. SMITH, 1969, p. 153). Assuming 200 fleeces per sack (PELHAM, 1936, pp. 242-43) this came to about 68 sacks of wool.

[30] 1969, p. 156.

[31] 1969, p. 156.

[32] See LAYARD and WALTERS, 1978, pp. 68-75, 93-6.

[33] Of course the aggregate supply curves of both labour and land are positively sloped. Implications would require marginal adjustments if the working out of the model resulted in changes in real wages or rents in terms of grain and cloth. See also footnote 37.

[34] Note that the existence at any point in time of unrented land no more signifies that its marginal productivity is zero than the existence of an unrented apartment in a modern building requires explanation in terms of zero marginal utility of housing space.

[35] See, for example, TROW-SMITH, 1953, pp. 52, 56.

notion of the magnitude of the difference in land intensity between wool and grain can, perhaps, be gleaned from Davenport's study of Forncett manor in Norfolk. Beginning in about 1377-78 when the demesne was stocked with 200 sheep, sheep raising assumed a new importance in the manorial economy. That this trend was a general one in the surrounding area is suggested by several considerations.

> Westwood Ridding which had been arable in the early fourteenth century was leased as pasture. In 1394 three tenants paid fines for having folds for 100 sheep... By 1404 a considerable number of tenants had inclosed their lands in the open fields.[36]

Now in 1376-77, 232 acres of arable, formerly tenants' land which had been held in 7.5 acre messuages (essentially a farm-house with land annexed to it) were leased out. However, instead of the expected 31 messuages only 7 were formed. Counting each household as a unit of labour we find that the ratio of land to labour rose from 7.5 to 33.1 (232 acres divided by 7 households). Since the 232 acres were most likely used for sheep raising, the evidence suggests that wool production was probably more than four times as land intensive as arable cultivation.

Attention is next focused on the following identity:

$$\frac{\bar{S}}{\bar{M}} = \frac{S(G)}{M(G)} \cdot \frac{M(G)}{\bar{M}} + \frac{S(W)}{M(W)} \cdot \frac{M(W)}{\bar{M}}$$

where:

$\bar{S}$ = the amount of land in the economy
$\bar{M}$ = the amount of labour in the economy
$S(G)$ = the amount of land employed in the production of grain
$S(W)$ = the amount of land employed in the production of wool (i.e., $\bar{S} - S(G)$)
$M(G)$ = the amount of labour employed in the production of grain
$M(W)$ = the amount of labour employed in the production of wool (i.e., $\bar{M} - M(G)$).

In short, the (constant) economy-wide ratio of land to labour is a weighted average of the ratios of land to labour utilized in the wool and grain industries. The weights are the fractions of total labour (or, alternatively, of total land) employed in each industry.

When an export tax and/or monopsonist-monopolist policies reduce wool production, labour (and, of course, land) transfer to grain production.[37] That

[36] DAVENPORT, 1906, pp. 79-80.

[37] Snatches of direct evidence of this conversion may be cited. Durham Cathedral Priory grain sales became more important from 1340 to 1370 (HALCROW, 1955, p. 347).

is, the weight $\frac{M(G)}{\overline{M}}$ rises. But since $\frac{S(G)}{M(G)}$ must by assumption 3) be smaller than $\frac{S(W)}{M(W)}$, and $\frac{\overline{S}}{\overline{M}}$ is constant, the ratios of land to labour in the production of both wool and wheat must rise. The underlying economics is straightforward. The decline in the production of the land-intensive product (wool) causes a shortage of labour. Consequently the relative price of labour rises [38] inducing both industries to employ more land relative to labour.[39] The key point is that the increase in land-intensity reduces the yield of land, that is, grain output per acre planted falls.[40] This occurs, it should be noted, without reference to deterioration in the intrinsic quality of the economy's stock of land.

III

Can it be shown that, as the model predicts, the price of labour rose relative to the price of land during the period from 1336 to the Black Death? Raftis [41] provides data from the Inquisitions Post Mortem on the evaluation

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Bourchier Hall in northeastern Essex was a marshland manor principally devoted to wool production. Nevertheless in 1351 all the oats sown apart from 15½ acres were sown on land that had once been under pasture (Britnell, 1977, pp. 57, 62). Ramsey Abbey whose properties were concentrated in Huntingdonshire had, during the XIIIth century, rapidly increased its sheep flock and converted arable into pasture. However, according to Raftis (1957, pp. 162, 241) there was at least a "half-hearted" renewal of interest in arable farming after 1340. BRITNELL (1966, p. 384) presents data for Langenhoe manor in the sheep raising country of Essex near Colchester that exhibits a sharp increase in sown acreage. In 1324-5 the number of acres sown was 122.5 but the average for the years 1338-9, 1342-3, 1344-5, and 1347-8 was 151 acres or 23.3 per cent more than in 1324-5. The area under oats expanded more sharply than the area under wheat, especially in 1342-3. It would appear that the expansion in sown acreage was at the expense of pasture (pp. 380-1).

[38] Workers are not necessarily better off than before since the excise tax and monopolistic-monopsonistic policies are inefficient, i.e., they reduce total national output. However, MILLER and HATCHER (1978, pp. 51-3) point out that in the 1330s and 1340s agricultural money wages rose relative to the price of a composite unit of "consumables." (The latter includes grain but *not* woollen cloth. See BROWN and HOPKINS, 1962, p. 182). Possibly this may have coaxed some additional labour into the economy and mitigated the severity of the adjustments noted in the text.

[39] MILLER and HATCHER (1978, pp. 236-37) suggest that after 1325 (?) "on the Ramsey estates labour seems to have been used less intensively...".

[40] Given that land and labor are perfectly divisible, production of grain (or of wool) takes place in the region of the same homogeneity, determining one production function in which an increase in the ratio of land to labour reduces the average product of land and raises the average product of labour.

[41] 1974, Table I.

of income from land at specified villages within each of eight counties in the East Midlands. The availability of such data are, of course, dependent on accidents of mortality and geography. More importantly, as Raftis [42] notes, the basis of the income evaluations is not at all obvious. It must be assumed that they represent the average pattern of grain cultivation and grain prices over several years. Another difficulty is that the number of acres in a given village often differs drastically from one income evaluation to another. With the objective of securing more homogeneous land samples the analysis was restricted to those observations in which the numbers of acres evaluated differed by no more than 20 percent. Table 1 shows that on the average, arable land valuations per acre declined by about 18 percent from the period 1295–1324 to the period 1336–1348. The next step is to see what happened to wage rates.

In order to gauge wage trends the analysis was restricted to data for four narrow and well defined tasks whose characteristics are hardly likely to have changed very much over the period considered, namely threshing, reaping, mowing, and carpentry. The results shown in table 2 indicate that on the average money wage rates were virtually unchanged. (The overall median of the percentage changes in wage rates was $+0.8$ while the overall arithmetic mean was -0.15.) Thus it would appear that after the imposition of heavy export taxes on wool and before the Black Death, wages rose relative to land values just as the model predicts.

While this lies outside our formal two-product model, it is nevertheless worth noting that the rise in the relative price of labour caused by the decline in the production of (land-intensive) wool may explain significant changes in the English *cloth* industry. It appears that the onset of the difficulties of the older, urban textile centres of eastern England and of the rising fortunes of the rural industry can be traced to the late XIIIth and earlier XIV centuries.[43] According to Carus-Wilson [44] the changed pattern of regional specialization was due to a change in the process of fulling cloth [45] that "greatly reduced the labour force." Specifically, in compressing the cloth the arm-wielded mallet or the feet of a man were replaced by hammers on a revolving drum attached to the spindle of a water wheel.[46] The steeply graded streams needed to power water mills were abundant in newer cloth centres such as Gloucestershire, Somerset, and Wiltshire but scarce in older centres such as Lincolnshire. However, the invention and innovation of the fulling mill date well before the

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[42] 1974, pp. 16-17.

[43] Bolton, 1980, pp. 156-7; Carus-Wilson, 1952, p. 409. Phythian-Adams, 1971, pp. 165-6.

[44] 1952, pp. 409-10. See also Clarkson, 1971, p. 94.

[45] Fulling, that is, shrinking the cloth by beating it in water gave the material greater resistance to weather and wear.

[46] Carus-Wilson, 1952, pp. 380, 410; Usher, 1920, pp. 205-6.

TABLE 1

INQUISITIONS POST MORTEM VALUATIONS OF INCOME FROM ARABLE LAND IN THE EAST MIDLANDS

County Village	Average Number of acres (weight) *	Valuation (pence per acre) 1295-1324	Valuation (pence per acre) 1336-1348	Arithmetic Mean of (1) and (2)	Percentage change in valuation (2)-(3) / (4)
	(1)	(2)	(3)	(4)	(5)
Bedfordshire					
Wooton	43 (.015)	3	4	3.5	28.6
Buckinghamshire					
Hambleden	320 (.114)	3	3	3	0
Adstock	120 (.043)	6	4	5	— 40.0
Holmer Green	80 (.028)	3	2	2.5	— 40.0
Hertfordshire					
Little Berkhamsted	320 (.114)	4.5 **	3	3.75	— 40.0
Rabley heath	82 (.028)	4	6	5	40.0
Huntingdonshire					
Hamerton	85 (.030)	8	3	5.5	— 90.9
Yelling	220 (.078)	4	3	3.5	— 28.6
Little Paxton	40 (.014)	2	4	3	66.7
Leicestershire					
Buttesford	197 (.070)	12	6	9	— 66.7
Northamptonshire					
Puxley	14 (.005)	6	4	5	— 40.0
Mears Ashby	38 (.013)	5	4	4.5	— 22.2
Titchmarsh	440 (.157)	6	6	6	0
Stoke Abory	270 (.096)	4	4	4	0
Milton	200 (.071)	6	4	5	— 40.0
Nottinghamshire					
Kingston	60 (.021)	4	3	3.5	— 28.6
Rutland					
Oakham	270 (.096)	20	20	20	0
				Median	— 28.6
				Simple Arithmetic Mean	— 17.7
				Weighted Arithmetic Mean	— 18.5

* Weights are the fraction of total acres (2799) for each set of valuations. (Weights do not sum to one due to rounding).

** Average of valuations for 1295 and 1305.

Source: Raftis, 1974, Table 1.

end of the XIIIth century. It was introduced into England in the late XIth or XIIth century and in Brabant and Flanders several towns had introduced the mill as early as the XIIth century.[47] In England, Carus-Wilson [48] believes, the fulling mill was at first employed to meet the cloth needs of local rural populations. I would surmise, therefore, that the widespread adoption of water power was due not to labour-saving technical progress but to a rise in the relative price of labour. Only after wages had risen could cloth production costs be reduced by "automating," that is, substituting power for manual fulling. This hypothesis finds support in the report that during the XIVth century the Low Countries, with the exception of several places in Artois, abandoned the use of fulling mills.[49] A related point of some interest is that the rise of English worsted, a lighter cloth unthickened by fulling, seems to date from the same period.[50] I am suggesting that the increased relative price of labour lowered the price of (unfulled) worsteds relative to that of (fulled) broadcloths.

IV

Titow's [51] data on Winchester manor yields were utilized to study changes in the average productivity of land. Our model, it will be recalled, predicts that an increase in the wool export tax will cause a decline in wool production, a rise in the land-intensity of grain production, and, consequently, a decline in yields of grain per unit of land. Given the concentration of Winchester manors on the downs north of Winchester this decline should be quite perceptible. In the downs there is no hard and fast line between arable and pasture, and the transition from wool to grain can therefore be relatively swift and painless.[52]

First the impact of the 6.67 s. export tax of 1275 was considered by comparing Titow's Periods I (1271-99) and II (1271-99). It was found that the expected decline in wheat yields per acre took place in only 53 percent of the Winchester manors as opposed to 81 percent for barley and 90 percent for oats. The arithmetic mean percentage decline in yields per acre were 2 for wheat, 22 for barley, and 21 for oats. Taking all three grains together yields

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[47] Bolton, 1980, p. 157; Van der Wee, 1975, p. 209.

[48] 1954, p. 203.

[49] Van der Wee, 1975, p. 209; Van Houtte, 1977, p. 82.

[50] See Gregg, 1976, p. 48. In the mid-XIVth century 15-20 percent of English cloth exports were worsteds which began to appear early in the century in the purchases of the royal wardrobe (Bolton, 1980, pp. 200-1). East Anglia had few sources of water power but its proximity to the Continent and ample supplies of soft water made it England's most important worsted producer (Stamp and Beaver, 1971, pp. 492-3).

[51] 1972.

[52] Levett, 1916, p. 130; Thirsk, 1967, pp. 41-2.

TABLE 2

WAGE RATES FOR THRESHING, REAPING, MOWING, AND CARPENTRY

I *Annual Data*

A. *Clare manors*[1]

Years	Reaping wheat (pence per acre)	Threshing wheat (pence per quarter)
(1) 1304-35	5.78	2.82
(2) 1336-48	5.04	2.50
(3) Percentage Change (on base mean of (1) and (2))	— 13.7	— 5.7

B. *Thorold Rogers*[2]

Years	Reaping wheat (pence per acre)	Mowing (pence per acre)	Highest wage for threshing wheat by region[3] (pence per quarter)				
			E	M	S	W	N
(1) 1295-1335	5.80	5.52	3.09	2.56	2.66	2.42	2.55
(2) 1336-1348	5.69	5.38	3.00	2.35	2.77	2.20	2.67
(3) Percentage Change (on base mean of (1) and (2))	— 2.2	— 2.6	—2.9	—0.8	3.7	—9.5	4.6

II *Decadal Data*[4]

Years	Threshing and winnowing (pence per 3 rased quarters of wheat, barley, and oats)		
	Winchester (eight manors)	Esher	Westminster manors
(1) 1290-1339)	4.20	4.84	7.06
(2) 1340-1348	5.03	5.11	7.41
(3) Percentage Change (on base mean of (1) and (2))	18.0	5.4	4.8

Years	Reaping and binding by contract in Winchester manor of Overton (pence per acre)	Carpenters (pence per day) Winchester	Westminster	Hinderclay
(1) 1290-1339	2.70	3.27	4.15	2.90
(2) 1340-1348	2.77	2.96	4.26	3.00
(3) Percentage Change (on base of mean of (1) and (2))	2.5	—10.0	2.6	3.4

[1] *Source*: Holmes, 1957, p. 91.

[2] *Source*: Rogers, 1866, Tables 1 and 2.

[3] E = East: Lincolnshire, Norfolk, Essex, Suffolk, and Kent.
M = Midland: Oxford, Bucks, Rutland, Northampton, Cambridge, Hunts, Beds, Middlesex, Herts, and Leicester.
S = South: Hants, Surrey, Sussex, Dorset, Wilts, Berks.
W = Gloucester, Hereford, Somerset, Warwick, Worcester, Devon, South Wales.
N = North: York, Notts, Cheshire, Cumberland, Durham, Derby, Salop, North Wales.

[4] *Source*: Beveridge, 1955, Tables 1-3.

declined in 75 percent of the cases (71 out of 95) while the arithmetic mean percentage decline in yields per acre amounted to 15 percent. The sharp contrast between the behaviour of wheat yields and those for barley and oats strikes a discordant note. Possibly it has to do with the types of land released from sheep raising on the Winchester manors.[53] And this release certainly occurred. From Period I to Period II the total number of sheep on the Winchester manors declined from 20,164 to 16,968, or by 17 percent.[54] Moreover, the median percentage decline in Titow's "combined average yields per acre" for those manors with a greater than median percentage decline in sheep numbers was 18.4 as opposed to 13.3 for manors with a smaller than median decline in sheep numbers. Thus, manors experiencing an above average decline in wool production also experienced a 32 percent greater decline in grain yields than those experiencing a below average decline in wool production.

The evidence is consistent with our model which stresses changes in land-intensity as the determining factor in grain yields. It may well be that the marked deterioration of Winchester yields per acre in the last quarter of the XIIIth century can be explained without reference to changes in the intrinsic quality of land.

In order to ascertain the impact of the much larger export taxes after 1336, average grain yields per acre in 1325-35 were compared to those for 1336-48. The results were generally in the expected direction but rather weak. The expected decline in barley yields per acre took place in only 48 percent of the manors as opposed to 80 percent for wheat and 79 percent for oats. The arithmetic mean percentage changes in yields per acre were — 11.3 for wheat, — 7.6 for oats, and + 6.3 for barley. Taking all three grains together, yields declined in 70 percent of the cases (65 out of 93) while the arithmetic mean percentage decline in yields per acre was 4 percent. It is not possible to compare sheep numbers for 1325-35 with those for 1336-48 because Titow provides only average numbers of sheep for the entire 1325-49 period.

* * *

Obviously we need more yield data as well as a more detailed multivariate analysis of the existing data. Nevertheless it can be fairly concluded that the non-neoMalthusian model of grain yields and relative factor prices presented in this paper is not inconsistent with the available evidence.

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[53] See footnote 36 above.

[54] The totals are the sums of the average numbers of sheep per manor for Period I and for Period II.

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