NOTES

Income Elasticities of Demand and the Release of Labour by Agriculture during the British Industrial Revolution

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I

There has been little attention given to the role of the pattern of demand in the transfer of labour from agriculture to industry during the British Industrial Revolution.[1] This is despite the prominence of Engel effects in many economists' models of economic development. The few discussions which do exist indicate an expectation that the income elasticity of demand for food in the eighteenth century may have been high.[2] If this was so, it could be expected to slow down the rate of industrialisation, *ceteris paribus*.

On the other hand there has been great interest in the nature of improvement during the so-called Agricultural Revolution. The post-war literature *appears* [3] to deny that agriculture released labour to industry during this period. Jones sums up one of the best known surveys thus: " It would be tendentious to praise agriculture because its inability to release enough labour prompted inventiveness, but it must be concluded that it was not usually an immediate source of labour

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[1] See the discussion and bibliographic references in A. C. KELLEY, and J. G. WILLIAMSON, *Lessons from Japanese Development* (Chicago, 1974), ch. 10.

[2] N. F. R. CRAFTS, " English Economic Growth in the Eighteenth Century: A Re-examination of Deane and Cole's Estimates ", *Economic History Review* 2nd Ser. XXIX (1976), p. 230 and R. A. IPPOLITO, " The Effect of the ' Agricultural Depression ' on Industrial Demand in England ", *Economica* XLII, (1975), p. 305.

[3] But see below p. 167.

for industry "[4] Timmer concluded that "The English agricultural revolution increased land, not labor, productivity".[5]

Yet, paradoxically it would seem, structural change in England was rapid between 1700 and 1850. Deane and Cole suggest that the proportion of the labour force in agriculture was between 60 and 80 per cent in Gregory Kings' time, was 36 per cent in 1801 and 22 per cent in 1841, the last census prior to the abolition of the Corn Laws.[6]

This paper re-examines the paradox. Section II discusses and extends the evidence on the income elasticity of demand for food and suggests that it was indeed high. Section III reviews the concept of labour release in terms of the concept of a viable economy and indicates the role which income elasticities play. Section IV pulls together these threads and relates them to the available evidence to suggest that it is clear using an appropriate conceptual framework that labour was released by agriculture in eighteenth and early nineteenth century Britain, that there are substantial grounds for inferring that output per man in agriculture was being augmented considerably from at least 1700 on and that, given demand patterns, it is not at all surprising that numbers in agriculture grew during the Industrial Revolution. Section V considers the implications of these results and summarises the conclusions of the paper.

II

Evidence on income elasticities has proved hard to come by for the industrial Revolution period. Both Crafts and Ippolito relied on inferences from twentieth-century data. Crafts argued the income elasticity of demand for agricultural output was likely to be between 0.5 and 0.7 based on FAO developing countries data, whilst Ippolito suggested 0.5 to 0.75 based on Houthakker's and Stone's studies of Britain in the twentieth century.[7] Both papers were interested in revising accepted notions about agricultural growth and its rela-

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[4] E. L. Jones, *Agriculture and the Industrial Revolution*, (Oxford, 1974), p. 102. For similar statements see J. D. Chambers and G. E. Mingay, *The Agricultural Revolution, 1750-1880*, (London, 1966), pp. 98-9 and P. Deane, *The First Industrial Revolution*, (Cambridge, 1965), pp. 43-50.

[5] C. P. Timmer, "The Turnip, the New Husbandry and the English Agricultural Revolution", *Quarterly Journal of Economics* LXXXIII (1969), p. 392.

[6] P. Deane and W. A. Cole, *British Economic Growth, 1688-1959*, (Cambridge, 1969), pp. 137, 142.

[7] Crafts, *op. cit.*, p. 231; Ippolito, *op. cit.*, p. 305. The Studies cited by these authors are F.A.O., *Commodity Review. (Special Supplement) (Rome, 1962)*, H. S. Houthakker, "An International Comparison of Household Expenditure Patterns commemorating the Centenary of Engel's Law", *Econometrica* XXXIII (1957), pp. 532-551, R. Stone, *The Measurement of Consumer's Expenditure and Behaviour in the United Kingdom 1920-1938* (Cambridge, 1954).

tionship with the rest of the economy and in both cases the conclusions could be sensitive to the value of the income elasticity of demand for food.

Two kinds of evidence can be used to glean information on income elasticities during the Industrial Revolution. First, there is cross-section data from budget studies. Very few of these exist but there are three investigations which can be utilised. These were made by Davies c. 1790 and Eden c. 1795 for poor, mainly agricultural workers, and Neild for rather better off Lancashire industrial workers in 1836.[8] Secondly, given information over time on the growth of real income and population, on consumption of agricultural products and their prices, we can deduce a time series value for the income elasticity of demand for agricultural output for the economy as a whole.

Let us consider first the budget studies. Since there are other well-known historical budget studies by Houthakker and by Williamson,[9] it is thought worthwhile to present in detail what can be obtained from the studies by Davies, Eden and Neild, even though in each case the number of observations is small. All these studies were, of course, motivated by a desire to investigate the extent of poverty.

Each of the budget studies was presented with a detailed commentary by the author and it is clear that they were all conducted with great scrupulousness. Nevertheless there are problems with the data which reduce the number of budgets which are usable for present purposes. In particular, care was taken to include in the regressions only those budgets where expenditure was reported on each of the categories rent, fuel, clothing and food and only those households consisting of man, wife and children. No attempt was made, however, to consider children in terms of adult equivalents because age information is not generally available.

A more important problem concerns the income variable. Modern investigators usually work in terms of expenditure rather than earnings because it is believed such data are less liable to error and more likely to represent permanent income. Each of the budget studies presented a difficulty. Davies's study gives earnings and expenditure on food in detail but does not give details of other expenditures or total expenditures. Earnings were therefore used as the independent variable. Neild's study is similar. He presents evidence for two years, 1836, a 'normal' year, and 1841, a year of depression. Income elasticities were estimated for 1836 again using earnings as the independent variable. Eden's

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[8] D. DAVIES, *The Case of Labourers in Husbandry* (Bath, 1795), F. M. EDEN, *The State of the Poor* (London, 1797), W. NEILD, "Comparative Statement of the Income and Expenditure of Certain Families of the Working Classes in Manchester and Dukinfield, in the Years 1836 and 1841", *Journal of the Statistical Society* IV (1841), pp. 330-334.

[9] J. G. WILLIAMSON, "Consumer Behaviour in the Nineteenth Century: Carroll D. Wright's Massachusetts Workers in 1875", *Explorations in Entrepreneurial History* 2nd ser. IV (1966-67), pp. 98-135.

study mostly concerns 1795/6, a period of high food prices.[10] Expenditure is itemised in some detail by Eden and total expenditure was recorded. Expenditure was therefore used as the independent variable. However, many of the households reported expenditure far in excess of earnings and Eden himself expressed suspicion of the accuracy of their budgets. It was therefore decided to exclude all observations for which expenditure exceeded earnings by more than £ 3 per year (about 1/8 th of the average budget in the sample).[11]

Estimates of the expenditure elasticity of demand for food for the Eden study and the income elasticity of demand for food for the Davies and Neil studies were obtained from the following regression equation:

$$\log F = \alpha + \beta \log \gamma + \gamma \log N \qquad (1)$$

where F is expenditure on food, γ is expenditure (or earnings) and N is the number in the family. β is, of course, directly interpretable as the expenditure (income) elasticity of demand for food.[12] There are two estimation problems to be noted. For the studies based on earnings, if there are errors of measurement of earnings, this can be expected to give a downward bias to the estimate of β. For the study based on expenditure there is the possibility that the regression of a part expenditure against the whole will impart an upward bias to the estimate of β.

Income and expenditure elasticities of demand for food estimated from the budget studies are reported in Table 1, together with results obtained in earlier papers by Houthakker and Williamson. For the Eden study it was possible also to derive estimates of the expenditure elasticity of demand for housing and clothing, and for the Neild study the income elasticity of demand for housing could be obtained. These figures are reported although not a main concern of this paper. Standard errors are given in parentheses.

We see from Table 1 that the estimated elasticities of demand for food in England during the Industrial Revolution are high, and in the case of the Davies and Eden studies are not significantly different from 1. However, before jumping to the conclusion that the income elasticity of demand for food was high for the economy as a whole two points should be noted. First, although all the estimated coefficients are significantly different from zero at the 1 per cent level, the small sample size has left quite large confidence intervals. For example, the Neild study coefficient is not significantly different from 0.4

[10] Eden reports a few budgets for other years but these were not used.

[11] Estimates were also obtained for the sample including households with a deficiency of more than £3 per year and the expenditure elasticity of demand for food obtained was 1.000 with a standard error of .028; there were 49 observations.

[12] Estimates of these elasticities were also derived using a semi-log functional form. They were generally similar and do not give any reason to doubt the argument developed later. The estimated elasticities were 0.953 (for Davies), 1.069 (Eden) and 0.853 (Neild).

TABLE 1

EXPENDITURE ELASTICITIES OF DEMAND

	Food			Clothing			Housing		
	β	γ	R^2	β	γ	R^2	β	γ	R^2
Neild Data (N = 14)	0.668	0.141	0.931				0.633	0.118	0.792
	(0.134)	(0.140)					(0.235)	(0.243)	
Eden Data (N = 24)	1.003	— 0.008	0.972	1.095	— 0.181	0.392	0.651	— 0.103	0.399
	(0.043)	(0.046)		(0.330)	(0.354)		(0.194)	(0.208)	
Davies Data (N = 32)	0.876	0.132	0.624						
	(0.138)	(0.097)							
U.K. Working Class 1937/8 [a]	0.594	0.294		1.042	0.143		0.553	— 0.072	
	(0.021)	(0.019)		(0.029)	(0.026)		(0.026)	(0.023)	
U.K. Middle Class 1937/8 [a]	0.344	0.386		1.342	— 0.111		0.346	0.145	
	(0.019)	(0.021)		(0.154)	(0.169)		(0.031)	(0.034)	
Germany 1907 [ab]	0.537	0.261		1.498	0.061		0.913	— 0.154	
	(0.018)	(0.015)		(0.045)	(0.038)		(0.026)	(0.022)	
U.S.A. 1901 [ac]	0.712	0.158		1.435	0.016		0.839	— 0.111	
	(0.004)	(0.002)		(0.019)	(0.012)		(0.016)	(0.010)	
Massachussets 1875 [d]	0.607	0.303		1.821	— 0.274		1.436	— 0.463	
	(0.027)	(0.021)		(0.063)	(0.049)		(0.070)	(0.055)	
Skilled Workers, Mass. 1875 [d]	0.570	0.320		1.569	— 0.140		1.511	— 0.496	
	(0.069)	(0.040)		(0.109)	(0.074)		(0.133)	(0.091)	
Unskilled Workers, Mass. 1875 [d]	0.730	0.178		1.808	— 0.167		1.367	— 0.427	
	(0.038)	(0.040)		(0.118)	(0.123)		(0.124)	0(.129)	

a. Reported in Houthakker, *op. cit.*; estimates also based on log-log functional form.
b. City dwellers.
c. Industrial workers.
d. Reported in Williamson, *op. cit.*; industrial workers; estimates also based on log-log functional form.

and the Davies coefficient not significantly different from 0.6 at the 5 per cent level. Second, the samples are drawn from restricted income ranges, indeed from very poor families in two cases. The average yearly earnings for the Davies sample was £ 4.8 per head compared with a national income of £ 10.6 per head, for the Eden sample £ 5.7 compared with a 1795 national income of £13.8 per head, and for the Neild sample £ 15.2 compared with a national income per head of £ 22.6 in 1836.[13] Naturally the results may not apply to income disposed of by higher-income families.

We can proceed to put a lower bound on the value of the income elasticity of demand for food during the Industrial Revolution and also make a 'best guess' at its value as follows. Suppose the Davies sample is typical of the very poor who in the eighteenth century received about 35 per cent of income according to Gregory King's figures and that the Neild coefficient applies to middle incomes who received about 40 per cent of income.[14] Assume that the rich recipients of the remaining 25 per cent of income had an income elasticity of demand for food of 0.4, a little higher than that of the 1937/8 English middle class. Then using these weights a best guess at the income elasticity of demand for food for the economy as a whole can be obtained using the point estimates of Table 1. This turns out to be $(0.4 \times 0.25) + (0.67 \times 0.4) + (0.88 \times 0.35) = 0.68$. The lower bound may be derived by assuming that the true income elasticities are the extreme lower figures of the 95 per cent confidence intervals around the estimated coefficients. This would yield a figure of 0.46.

The gap between these two figures is rather large for comfort and it is therefore useful to turn for further evidence to the second, time series approach. This can only be employed for the nineteenth century when the Deane and Cole national income estimates commence.[15] The method is straightforward. If relative prices are stable, then the following relationship holds[16]

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[13] The national income figures were obtained as follows. For 1790 national income in current prices was estimated using Deane and Cole's estimate of £ 232 m. for national income in 1801, Deane and Cole, *op. cit.*, p. 166, and working back using their real output index, *ibid.* p. 78 and converting to current prices using the Schumpeter-Gilboy price index, see B. R. Mitchell and P. Deane, *Abstract of British Historical Statistics* (Cambridge, 1962), p. 469. 1795 was treated similarly and interpolating the real output index. 1836 was obtained by interpolation from Deane and Cole's national income benchmark year figures, *op. cit.*, p. 166.

[14] The King figures are reprinted in P. Mathias, *The First Industrial Nation* (London, 1969) p. 24. In obtaining the income shares it was assumed that the Davies figures applied to those with incomes $<$ £ 10 per head and the Neild figures to those with incomes $\geqslant$ £ 10 and $<$ £ 20 per head.

[15] This is because the Deane and Cole figures for both agricultural output and real national output are based on an implicit assumption about the income elasticity of demand for food; see Crafts, *op. cit.*, p. 231.

[16] Strictly speaking it is also necessary to assume no economies of scale in demand

$$\dot{Q}ag/Qag = \varepsilon \cdot (\dot{Y}/\dot{P})/(Y/P) + \dot{P}/P \qquad (2)$$

Where Qag is the supply of agricultural goods, ε is the income elasticity of for food, Y/P is income per head, P is population and the dot denotes a time derivative. Given information on P, Y and Qag an estimate of ε can be obtained using (2). We chose to apply this method to the period 1820–40 when relative prices were stable [17] and there were no major disturbances due to war or tariff changes. The results were as follows [18]

$$2.01 = \varepsilon \cdot 0.85 + 1.38 \qquad (3)$$

and so ε is estimated to be 0.74.

The two different approaches have yielded very similar results and it is suggested that the income elasticity of demand for food in Britain during the Industrial Revolution was of the order of 0.7. If this view is accepted, then the recent investigators, Crafts and Ippolito, were on the right lines and there is no reason on this score to criticise their main conclusions. Although Britain was an early and rapid industrialiser, her case was apparently different from Japan, a country in which it has been argued that rapid industrialisation was much helped by a low income elasticity of demand for food.[19]

III

It was pointed out in Section I that from 1700 on the British economy experienced a rapid industrialization of the labour force. This section briefly considers the role of agriculture in this process. The focus is on the concept of the 'release of labour' from agriculture to industry. The emphasis of the

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for food and no changes in tastes. The former assumption is consistent with our γ estimates in Table 1 for this period.

[17] See the Rousseaux price indices for agricultural and industrial goods in MITCHELL and DEANE, *op. cit.*, p. 471.

[18] The figures in (3) were derived as follows, $\dot{P}/P$ from MITCHELL and DEANE, *op. cit.*, p. 6, $\dot{Y}/Y$ (and hence $(\dot{Y}/P)$ (Y/P)) from DEANE and COLE, *op. cit.*, p. 166. The supply of agricultural goods domestically was obtained from Deane and Cole's estimate of agricultural incomes *op. cit.*, p. 166. Imports were assumed to grow at the rate of growth of retained imports, derived from MITCHELL and DEANE, *op. cit.*, pp. 282-3, and to be equal to 10 per cent of food supplies in 1820. Both these figures are slightly conservative given Deane and Cole's discussion, p. 32 and p. 310; (if imports were, say, 35 per cent foodstuffs and equal to about 12 per cent of national income in 1820, then retained imports of food would equal 4.2 per cent of national income, whereas agricultural output was 26 per cent of national output).

[19] See KELLEY and WILLIAMSON, *op. cit.*, ch. 10; ε for Japan has been held to have been as low as 0.2 during Meiji times, Kelley and Williamson, p. 160.

discussion is on agriculture's ability to transfer labour to industry, although, of course, the successful implementation of the transfer required that industry had the capability to employ the released labour. The argument is developed in terms of an economy whose food is entirely domestically produced and in which the relative price of food is constant. This is a helpful, simplifying device but is in any case appropriate for an *ex-post* view of 1700-60 which will be our first concern in Section IV. The role of changing prices and imports will be introduced in Section IV in comparing 1700-60 with the later period of the classic Industrial Revolution.

The crux of the industrialization problem for an economy like eighteenth century Britain is as follows.[20] Suppose agriculture is characterised by diminishing returns to labour. Suppose also that food demand grows at the same rate as population. Then, if the relative share of the labour force in agriculture is to fall, i.e. industrialization is to occur, it is neccessary that the growth rate of the labour force in agriculture must be less than the growth rate of population (and the labour force) overall. This appears to pose problems, for whilst the demand for food grows with population the food supply grows less rapidly even if all the extra labour is used in agriculture (which would, of course, amount to a deindustrialization). Clearly to home feed all the extra population and also industrialize by having the agricultural labour force growing less rapidly than labour as a whole it would be necessary to have output per man in agriculture rising. This in fact is the crucial condition for the ' viability ' of the economy. Obviously, if demand were growing faster than population as a result perhaps of rising per capita incomes, the preceding arguments hold *a fortiori*. Since it is supposed that there are diminishing returns to labour in agriculture, industrialization requires some other force such as technical progress or capital accumulation to raise output per man in agriculture by more than offsetting the diminishing returns.

The point can be elaborated as follows. The production function in agriculture is assumed to be

$$Q_t = Ae^{\mu t} \quad L_t^{\alpha} \quad (0 < \alpha < 1) \tag{4}$$

where μ represent the rate at which capital accumulation and technical progress are augmenting output. The rate of growth of food supply is therefore

$$\dot{Q}/Q = \mu + \alpha . \dot{L}/L \tag{5}$$

Since we are assuming constant prices the growth of demand for food is the right hand side of equation (3) and for demand to remain equal to supply we have

$$\mu + \alpha . \dot{L}/L = \varepsilon(\dot{Y}/Y - n) + n \tag{6}$$

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[20] This section has benefited greatly from reading A. K. Dixit, Theories of the Dual Economy: A Survey, (mimeo) (Berkeley, 1969).

where n is the rate of population growth. This can be rearranged to give the required rate of growth of the agricultural labour force to meet the growth in demand for food as

$$\dot{L}/L = \frac{\varepsilon(\dot{Y}/Y - n) + n - \mu}{\alpha} \tag{7}$$

For industrialization $\dot{L}/L$ has to be less than n. If this condition is met then the economy can be said to be viable in the sense that the food requirements of the extra population can be met by a rate of increase of the labour force in agriculture less that the rate of increase of the labour force and population as a whole. Then some labour is released for use in industry and the food requirements of the population can be met a lower share of the labour force.

This release of labour requires (using (7))

$$\frac{\varepsilon(\dot{Y}/Y - n) + n - \mu < n}{\alpha} \tag{8}$$

which can be rearranged to give

$$\mu - (1 - \alpha)n - \varepsilon(\dot{Y}/Y - n) > 0 \tag{9}$$

We can use (9) to consider what is required for the release of labour by agriculcure. Even if there is no increase in income per head or zero income elasticity of demand for food, with population growth we need $\mu > 0$ because $\alpha < 1$. Given α the faster is population growth the higher needs to be μ. That is industrialization would require that capital accumulation and technical progress in agriculture more than outweighed dominishing returns to agricultural labour so that output per man in agriculture rises. Inequality (9) also reveals that the necessary μ for industrialization will be raised for faster growth of income per head and/or a higher income elasticity of demand for food.

We can also consider the likelihood of there actually being falls in the absolute size of the agricultural labour force using eqn. (7). This shows that to get a decline in the agricultural labour force we need $\mu > \varepsilon(\dot{Y}/Y - n) + n$. This is a more stringent condition than meeting inequality (9), which merely required $\mu > \varepsilon(\dot{Y}/Y - n) + (1 - \alpha)n$. It is therefore quite possible to find (9) is met whilst the agricultural labour force is growing in absolute size.

The (closed economy, constant price) model that we have used suggests the following conclusions. Properly conceived, the release of labour from agriculture to industry is concerned with a decline in the proportion of the labour force in agriculture not a decline in absolute numbers. The important thing is the ability of the economy to meet the *extra* food requirements occasioned

by growth of population and incomes whilst allowing the share of industry in the labour force to rise. Indeed we might expect to observe that the release of labour implied by a decline in the proportion of labour in agriculture would coincide with a rise in the numbers in agriculture. The achievement of viability or a decline in the numbers in agriculture is made harder by higher income elasticities. To achieve a decline in the proportion of the labour force in agriculture the vital point is that output per man in agriculture has to be rising and so the economy has to find a way to overcome diminishing returns to labour in agriculture.

IV

We are now in a position to reconsider structural change during the Industrial Revolution using the results of Sections II and III. We turn first to the period 1700-60. Agricultural prices in relative and absolute terms were about the same at the beginning and end of the period [21] and it is generally assumed that imports can be ignored for this period so the model of Section III is applicable. There are, however, some data problems to be considered.

The basic source of information is, of course, Deane and Cole, but their figures need some revision. Crafts pointed out that their method of estimating agricultural output was not compatible for 1710-40 with a positive income elasticity of demand for food.[22] Since agricultural output was a large part of total output, any revision of the agricultural output figures would also have a significant impact on Deane and Cole's estimates of the growth of real output per head. Also Deane and Cole relied on the Brownlee population figures whereas recent work by Lee based on the research of the Cambridge Group has shown that Brownlee's method led him to underestimate population growth prior to 1750. Lee's estimates give a figure of 5.07 million for the population of England and Wales in 1700 (compared with Brownlee's figure of 5.83 million) which grew to Brownlee's figure of 6.57 million in 1760.[23]

With this information and the estimate from Section II that the income elasticity of demand for food was 0.7 the growth rates of agricultural output and national output per head can be estimated for 1700-60 using the method proposed by Crafts.[24] This procedure gives the results of Table 2.

Note that the figures of Table 2 satisfy eqn.(3) given that $\varepsilon = 0.7$.

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[21] See the data in DEANE and COLE, *op. cit.*, p. 91.

[22] CRAFTS, *op. cit.*, pp. 230-1.

[23] R. D. LEE, "British Population in the Eighteenth Century", in R. C. FLOUD and D. N. MCCLOSKEY (eds.), *The Economic History of Britain since 1700* (Cambridge, forthcoming).

[24] CRAFTS, *op. cit.*, pp. 228-31. Note that since the price of agricultural goods was the same in 1700 and 1760 this amounts to using eqn. (3) of the present paper.

TABLE 2

GROWTH RATES OF AGRICULTURAL OUTPUT AND TOTAL OUTPUT 1700-60

	(per cent per year)
Agricultural Output	0.70
Population	0.44
Total Output per Head	0.37

Source: See text.

How was this 0.7 per cent per year growth rate for agricultural output achieved? In terms of eqn. (5) above we need to evaluate $\dot{L}/L$, α and μ. We can estimate $\dot{L}/L$ using the Lee population figures with estimates of the percentage of the labour force in agriculture in 1700 and 1760. For 1760 we have Massie's figure of 50 per cent.[25] For 1700 Gregory King's figures could be used to suggest a range of between 60 and 80 per cent.[26] Suppose the lowest figure of 60 per cent is true; then the growth rate of the agricultural labour force would have been 0.13 per cent per year over 1700-60. This, of course, is a maximum figure. We propose to use this in order to bias our estimates of μ downwards, since the general tone of the literature has been to deny the importance of increasing ouput per man in agriculture.[27] Ippolito provided an estimate for α of 0.36.[28] On the same principle we round this up to 0.4. Substituting these figures into eqn. (5) we have

$$0.70 = \mu + (0.4)\ (0.13)$$

and hence $\mu = 0.65$.

Our review of 1700-60 suggests the following. First, it seems clear that output per man in agriculture was rising. Second, the agricultural labour force was growing less rapidly than population and the proportion of the labour force in agriculture was falling. Thus the economy was viable and labour was released by agriculture during this period prior to the classic Industrial Revolution, although the agricultural labour force may have been growing in absolute size. Third, the rise in output per man in agriculture was based on a positive value for μ of 0.65, a considerable achievement for the agricultural

[25] H. PERKIN, *The Origins of Modern English Society 1780-1880* (London, 1969), p. 125.

[26] DEANE and COLE, *op. cit.*, p. 137.

[27] See above, Section I.

[28] IPPOLITO, *op. cit.*, p. 308.

sector in augmenting labour productivity, although there is, of course, no way of saying how far this was due to technical progress.

We can also examine the role of the income elasticity of demand for food in structural change during this period. Table 3 gives illustrations in terms of three cases, the income elasticity of 0.7 believed to have actually applied, the estimate of 0.2 some writers believe obtained during the Japanese take off and the case of zero income elasticity of demand for food. This last case amounts, of course, to considering the growth of food demand for population growth alone. The object of Table 3 is to consider what would have been required of agriculture to meet different pressures of demand without prices rising and without extra food imports. We see that the level of μ, the rate of augmentation of agricultural output from technical progress and capital accumulation, would have been sufficient to generate a decline in the absolute numbers in agriculture had income per head not been growing or had the income elasticity of demand for food been at the unusually low Japanese level. Given the growth of incomes per head which occurred, the positive income elasticity of 0.7 about doubled the level of μ needed to achieve viability as compared with the requirements from population growth alone (at $\varepsilon = 0.0$).

TABLE 3

AN EX-POST VIEW OF THE RELEASE OF LABOUR FROM AGRICULTURE 1700-60 [a]

ε	μ for viability [b]	μ for $\dot{L}/L < 0$ [c]
0.7	> 0.52	> 0.70
0.2	> 0.34	> 0.51
0.0	> 0.26	> 0.44

Estimated Values [d] (per cent per year)

μ	0.65	n	0.44
$\dot{L}/L$	0.13	$\dot{Y}/Y - n$	0.37
$\dot{Q}/Q$	0.70	ε	0.70

a. All symbols are as defined in the text.
b. Using inequality (9).
c. Using eqn. (7).
d. For derivation of estimates see text.

The growth of the industrial labour force during 1700-60 was 0.75 per cent per year. Had the income elasticity of demand for food been at the Japanese level, then given the actual level of μ the economy *could* have had a rate

of growth of the industrial labour force of 1.11 per cent per year [29] and so the higher British income elasticity operated to slow down considerably the rate of industrialization. (What *would* have actually happened is, of course, beyond the scope of this kind of accounting model.)

We can now proceed to look at the problems posed for the release of labour from agriculture by the faster growth of incomes and population during the Industrial Revolution proper. We look at 1760-1800 and 1820-40 and omit 1800-20 because Deane and Cole's figures for agricultural incomes behave very erratically, as do agricultural prices, during 1800-20.[30]

TABLE 4

THE LABOUR RELEASE PROBLEM FOR AGRICULTURE IN THE INDUSTRIAL REVOLUTION IN THE COUNTERFACTUAL SITUATION OF NO PRICE CHANGES, NO FOOD IMPORTS BUT THE SAME ECONOMIC GROWTH RATES [a]

$\varepsilon\ \mu$ for viability		μ for $\dot{L}/L < 0$		$\varepsilon\ \mu$ for viability		μ for $\dot{L}/L < 0$	
0.7	> 0.88		> 1.22	0.7	> 1.43		> 1.98
0.2	> 0.62		> 0.96	0.2	> 1.00		> 1.55
0.0	> 0.51		> 0.85	0.0	> 0.83		> 1.38
Estimated Values [b] (per cent per year)							
μ	0.53	n	0.85	μ	1.27	n	1.38
$\dot{L}/L$	0.07	$\dot{Y}/Y - n$	0.53	$\dot{L}/L$	0.28	$\dot{Y}/Y - n$	0.85
$\dot{Q}/Q_c$	0.56	ε	0.70	$\dot{Q}/Q_c$	1.38	ε	0.70

a. This table is constructed analagously to Table 3.
b. Estimates for 1760-1800 are based on Deane and Cole, *op. cit.*, pp. 78, 142. μ is derived as it was for 1700-60. Estimates for 1820-40 are based on Deane and Cole, *op. cit.*, pp. 143, 166. The proportion of agricultural incomes going to labour still appears to be about 0.4 and so α is retained at that level for the calculation of μ; Deane and Cole, *op. cit.*, pp. 152, 166. Population figures from Mitchell and Deane, *op. cit.*, p. 6.
c. Refers to domestic agricultural output only.

For 1760-1800 we see from Table 4 that faster population growth alone doubled the μ needed for viability or to get a decline in the agricultural labour force in a constant price, no extra imports case. In fact, of course, the economy experienced both rapidly rising food prices [31] and a growth of imports during

[29] Based on $\Theta = 0.5$ and the identity that $n = \Theta\dot{L}/L + (1 - \Theta)\ \dot{L}_1/L_1$ where L_1 is the industrial labour force and Θ is the share of agriculture in the labour force.

[30] See DEANE and COLE, *op. cit.*, p. 166.

[31] The ratio of wheat to other prices rose from 110 in 1760 to 170 in 1800; DEANE and COLE, *op. cit.*, p. 166.

this period and the agricultural labour force grew only slowly, although μ did not meet the requirement for viability at $\varepsilon = 0.7$. The major change from "the earlier period was a faster growth of demand from..." growth of incomes per head and population rather than any great decline in μ.

For 1820-40 the requirements for viability were raised still further. μ was now much higher but the economy would not have been viable for a closed economy, no price change case given the income elasticity of demand for food at 0.7, although it would have been viable at the Japanese level of 0.2. In this period food imports were important but prices were stable. Again output per man in agriculture was rising rapidly as it did throughout our three periods. The growth of imports does not seemingly reflect a failure of productivity growth but rather demand pressure and, presumably, comparative advantage.[32] Given the very high rates of augmentation of output (μ) now required to get a reduction in the agricultural work force in the closed economy case it is not surprising that the labour force in agriculture grew along with the imports. As it was the economy would have been viable at $\varepsilon = 0.7$ provided incomes per head grew at less than 0.63 per cent per year.

Throughout these three periods the economy was able to meet the basic requirement of viability, namely to deal with the food demands of the extra population, i.e. to be viable at $\varepsilon = 0.0$, and in fact maintained high values for μ. This was achieved despite a big increase in population growth and despite taking a low share of the extra capital formation undertaken during the Industrial Revolution.[33] Thus agriculture appears to have been capable of a successful release of labour to industry.

V

The arguments of the last three sections have been that the income elasticity of demand for food was high, that the release of labour should be thought of in terms of meeting extra food requirements with a declining share of labour in agriculture and that output per man in agriculture rose substantially during the Industrial Revolution permitting labour release, although price changes and imports were also important in equilibriating the market for food.

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[32] The following labour productivity levels were estimated by Bairoch for c. 1860 in million direct calories per male worker: U.K.; 20.0, Continental Europe; 9.5. P. Bairoch, "Free Trade and European Economic Development in the Nineteenth Century", *European Economic Review* III (1972), p. 214.

[33] Recent estimates suggest a rise of total fixed capital formation in the economy at 1851-60 prices from £ 6.64 mn a year in the 1760's to £ 49.91 mn a year in the 1840's. Agricultural fixed capital formation rose from £ 2.18 mn to £ 5.64 mn in the same period; C. H. Feinstein, "Capital Accumulation and Economic Growth in Great Britain, 1760-1860", (mimeo, Cambridge, 1976), Table 6.

Why then did the authors of Section I appear to take a different view? The answer seems to lie in the historiography of the Agricultural Revolution and the conceptualization of labour release rather than in disagreement about fact. Recent work on the Agricultural Revolution owes an enormous intellectual debt to Chambers and tends to follow the analytic lead given by him in his seminal article.[34] In reacting to the views of writers such as Cole and Dobb, Chambers stressed two points in particular. First, that during the Industrial Revolution the adoption of new farming generated increases in the flows of labour services required in agriculture [35] and that the rural population was rising more or less everywhere.[36] Second, that the source of the supply of the industrial labour force was not agrarian change but population growth.[37]

Since Chambers wrote there has been a tendency to stress the rise in the absolute numbers of workers in agriculture and to downplay the fact that output per man in agriculture rose.[38] Timmer's work, as noted in Section I, suggests that the improvements available to agriculture raised labour inputs proportionately as much as yields. However, from the perspective of this paper, the point that should have been stressed in the literature is that the new farming gave the agricultural sector the chance to raise output per man per year by making fuller use of workers previously underemployed for much of the year, even though output per man hour worked rose hardly at all or even fell.[39]

More fundamental has been the failure to emphasise the decline in the percentage of the labour force in agriculture when thinking of the release of labour. Most authors have accepted that the extra population could be fed with a smaller fraction of the workforce in agriculture but have not recognised this as a release of labour, saying rather that population growth led to the industrialization of the labour force. Thus Deane says, " If the agricultural industry did not not actually supply the labour which the labour intensive techniques of the new industry demanded, it fed the increasing population from which the industrial labour force was drawn ".[40] Jones and Woolf say " labour was probably not released from agriculture during the first wave of change — mixed farming had heavy labour needs and the absolute number of farmhands actually grew — but the nation's food supply could be secured by an ever smaller *pro-*

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[34] J. D. CHAMBERS, " Enclosure and Labour Supply ", *Economic History Review*, 2nd ser. V (1952/3), pp. 319-343.

[35] *Ibid.*, pp. 332-3.

[36] *Ibid.*, p. 336.

[37] *Ibid.*, p. 338.

[38] For example, Chambers and Mingay mention this only parenthetically, *op. cit.*, p. 99 and Jones treats it as an afterthought, *op. cit.*, p. 102. An exception is P. MATHIAS, *The First Industrial Nation*, (London, 1969), pp. 67-8.

[39] TIMMER, *op. cit.*, pp. 392-4.

[40] DEANE, *op. cit.*, p. 48.

portion of the national workforce ".[41] The model of Section III shows that this is a release of labour by exposing the counterfactual.

There is more than a terminological difference between the analysis of the present paper and that of Chambers and his followers. Their view argues that population growth provided the labour supply for industry. Note, however, that had there been no population growth but income per head had grown at the historical rate, then, in terms of the present model, there would have been viability and a decline of the agricultural labour force given the values of μ which were achieved. For 1700–60 the required growth of agricultural output would have been 0.26 per cent per year as compared with $\mu = 0.65$, for 1760–1800, 0.37 ($\mu = 0.51$) and for 1820–40, 0.60 ($\mu = 1{,}27$). The counterfactual is clear (from equation (7)) – with no population growth there could have been an industrialization of the labour force in all periods with no imports and no price rises for agriculture. Thus not only was population growth not necessary for the industrialization of the labour force but it also 'caused' the rising agricultural labour force. It is also misleading to regard population growth as sufficient to generate the industrialization of the labour force. If μ had been less than the viability requirement for zero income per head growth population growth would generate de-industrialization in the constant price, closed economy, constant living standards case. For example, for 1700–60 had μ been zero then even the modest population growth of that era would have required a growth rate of the agricultural labour force of 1.10 per cent per year, which would have implied the industrial labour force was declining at 0.42 per cent per year.[42]

Finally, we can point to two corollaries of the high income elasticity of demand for food. First it means that economic growth brought strong demand pressure to bear on agriculture so that faltering supply growth could well generate in the short term market rises in agricultural prices, even in periods when the economy would have been viable if just called on to feed the extra population. Economic growth might well involve, as it did in the late eighteenth century, rapid changes in relative prices. Secondly, given the well documented, sluggish behaviour of money wage rates [43] and the very high share of expenditure on food in lower income budgets,[44] in the short term economic growth could well operate to the detriment of lower income groups. The implications for the distribution of the gains from industrialization in the early phases of the Industrial Revolution may be worth further consideration.

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[41] E. L. Jones and S. J. Woolf, "The Historical Role of Agrarian Change in Economic Development", in E. L. Jones and S. J. Woolf (eds.), *Agrarian Change and Economic Development*, (London, 1969), p. 15.

[42] Calculated in the manner noted in fn. 29.

[43] See M. W. Flinn, "Trends in Real Wages, 1750–1850", *Economic History Review*, 2nd ser. XXVII (1974), pp. 395–413.

[44] The families in the Davies sample used in Section II spent on average 68 per cent of their budget on food, in the Eden sample 72 per cent.