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I

Chapter II of British Economic Growth[1] represents a radical departure from earlier views of the eighteenth century. It suggests that there were two major turning points in the growth of the economy, in the 1740's and the 1780's, and that the classic innovations of the years after 1760 should be regarded as results rather than prime movers of growth. It is also argued that unfavourable intersectoral terms of trade for agriculture and absence of population growth inhibited economic growth up to the 1740's whereas rapid population growth, and associated with it high relative agricultural prices, stimulated economic growth thereafter by creating buoyant domestic market conditions for the industrial sector.

The purpose of this paper is to re-examine the construction of the real output index of Deane and Cole which constitutes the principal quantitative support for their hypotheses. In particular the plausibility of the assumptions used in the treatment of the agricultural sector is questioned in Section II. Alternative, and it will be maintained, more satisfactory assumptions are used to provide revised estimates in Section III, the implications of which are discussed in Section IV.

II

There has been relatively little discussion[2] of the construction of the real output index although it is centrally important for Deane and

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(1) P. Deane and W. A. Cole, British Economic Growth 1688-1959 (2nd edition, Cambridge 1967).

(2) See, however, J. F. Wright's review article, "British Economic Growth 1688-1959". Economic History Review, 2nd ser. XVIII (1965), 397-412.

Cole's arguments and it is based on a number of strong assumptions. These include the following propositions.

(i) Agricultural output growth as a whole is accurately represented by the growth of grain output. This is estimated by postulating a constant level of corn consumption per capita of 2.25 quarters per annum throughout the eighteenth century.(3)

(ii) Brownlee's population series for England and Wales is correct.(4) This is important because agricultural output (43% of the weighting of the index) varies almost directly with population, (following (i)), and rent and services output (20%) is assumed to move exactly with population.(5)

It is argued that (i) is at least not vitiated by the observed trends in agricultural prices.(6)

The assumptions (i) and (ii) are instrumental in providing the quantitative support for the turning point in the 1740's, faster agricultural output growth in the second half of the century and a close association between the growth of aggregate real output and population. These results are compatible with Deane's hypothesis that the critical developments in agriculture "were stimulated to an extent which is difficult either to measure or to overstress, by the high price of corn which distinguished the second half of the eighteenth century"(7) and Cole's counterfactual that

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(3) Deane and Cole, op.cit. 65.

(4) J. Brownlee, "History of the Birth and Death Rates in England and Wales, taken as a whole from 1570 to the present time", Public Health XXIX (1916), 221-22, 228-38.

(5) Deane and Cole, op.cit. 77.

(6) Ibid. p.66.

(7) P. Deane, The First Industrial Nation (Cambridge, 1965), p.46.

"if the rate of population growth had begun to accelerate gradually in the 1720's instead of to decline, the acceleration in the rate of economic growth which seems to have occurred just before mid-century would have taken place some twenty years earlier."(8)

A number of objections to this approach are possible.

(i) There are a number of reasons for being sceptical of the Brownlee population series, - including the use of constant correction factors for baptisms and burials, the possibility of errors in and atypicality of the Rickman parish register aggregates(9) - such that, even though the long term perspective of the series may be correct, there is a large likelihood of errors in the estimates of short term growth rates of population, and hence of the real output index, thus making confident identification of turning points impossible.(10)

(ii) McKeown, Brown and Record have recently argued that the population growth of the eighteenth century came about chiefly as a result of improved nutritional standards. They would presumably wish to challenge the combined use of an increasing population series and no change in consumption of agricultural products per capita.(11)

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(8) W. A. Cole, "Eighteenth Century Economic Growth Revisited", Explortations in Economic History X (1973).

(9) For a fuller argument see N. F. R. Crafts, "Local Population Studies in the context of Aggregate Estimates for the Eighteenth Century", Local Population Studies XIII (1974).

(10) See N. F. R. Crafts, "Some Aspects of Interactions between Economics and Demographic Circumstances in the Eighteenth Century", Exeter Papers in Economic History (forthcoming).

(11) T. McKeown, R. G. Brown and R. G. Record, "An Interpretation of the Modern Rise of Population in Europe", Population Studies XXVI (1972), 345-82. They assert that "British agriculture was not only feeding many more people; it was, at least until 1767, feeding them better; ibid. p.352.

(iii) Deane and Cole hypothesise that demographic growth was a stimulant to growth rates of income and income per head largely through favourable demand effects connected with improving terms of trade for agriculture. However, in general, economic theory can offer no presumption of a unique relationship between changes in population growth and income growth rates. An alternative hypothesis is readily available in the case of a Malthusian fluctuations model, which is frequently presented as being broadly relevant to pre-industrial European populations.(12) There a rise in population growth will tend to be associated with subsequent falls in income per head.

(iv) There exists also an influential school of thought which envisages the first half of the eighteenth century as a period when agricultural output and productivity were growing rapidly, which would stress the ability of the agricultural sector to respond to adverse prices with improvements and would strongly question the validity of the approximately zero rate of growth of agricultural output which the use of the constant per capita corn consumption gives for the years before 1740.(13)

III

As a justification for their procedure Deane and Cole argued that

(12) This would include as a variant Wrigley's homeostatic hypothesis, in which populations only expand to "optimum" rather than maximum numbers. See E. A. Wrigley, "Family Limitation in Pre-Industrial England", Economic History Review XIX (1966), 107.

(13) See A. H. John, "Agricultural Productivity and Economic Growth in England 1700-60", Journal of Economic History XXV (1965), 19-34; E. L. Jones, "Agriculture and Economic Growth in England, 1660-1750", Journal of Economic History XXV (1965), 1-18; E. Kerridge, The Agricultural Revolution (London 1967).

the course of prices over the eighteenth century at least did not vitiate their assumptions. They make two propositions. First, that for most of the period prices did not change violently with the corollary that the own price elasticity of demand for agricultural products remained (approximately) constant at a low value.(14) Second, that the effects on per capita consumption of forces shifting the demand curve to the right were offset by higher prices.(15) The arguments are presented for corn but in the context of the real output index are presumably extended by analogy to agricultural output as a whole.

No results of any tests of these hypotheses were presented, however. In this section the support of the price series for Deane and Cole's method is tested, whilst retaining all Deane and Cole's assumptions, as a check on the internal consistency of the real output index. Mellor's(16) interesting discussion of forces impinging on agricultural prices during development provides an approach which can be adapted for this purpose.

The use of some elementary economic theory yields the following expressions.

$$\frac{\dot{D}}{D} = n\left(\frac{\dot{Y/P}}{Y/P}\right) + \frac{\dot{P}}{P} \qquad (1)$$

$$\frac{\dot{P}_{ag}}{P_{ag}} = \frac{\frac{\dot{S}}{S} - \frac{\dot{D}}{D}}{e} \qquad (2)$$

$$\frac{\dot{S}}{S} = \frac{\dot{Q}_{ag}}{Q_{ag}} + \frac{\dot{I}_{ag}}{I_{ag}} \qquad (3)$$

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(14) Deane and Cole, op.cit. 66.

(15) Ibid. p.64.

(16) J. W. Mellor, The Economics of Agricultural Development (Ithaca, 1966), Ch. 4.

hence

$$\frac{\dot{p}_{ag}}{p_{ag}} = \frac{\left[\frac{\dot{Q}_{ag}}{Q_{ag}} + \frac{\dot{I}_{ag}}{I_{ag}}\right] - \left[n\left(\frac{\dot{Y/P}}{Y/P}\right) + \frac{\dot{P}}{P}\right]}{e} \qquad (4)$$

where $\frac{\dot{D}}{D}$ is the rate of growth of demand for agricultural products and $\frac{\dot{S}}{S}$ is the rate of growth of supply, (i.e. in terms of shifts of the curves), P is population, Y/P is income per head, Q_{ag} is domestic agricultural output, I_{ag} is agricultural imports, p_{ag} is the price of agricultural products with n their income elasticity and e their own price elasticity. $\dot{}$ denotes a time derivative and all variables are in real terms.

With the exception of n, e and p_{ag} values for these variables can be derived directly from Tables 17 and 19 in British Economic Growth. If n, e and p_{ag} were known, a check on the consistency of the Deane and Cole method would be to insert the "actual" values for all variables into (4) and see if the left and right hand sides were indeed equal.

Measurement of the real price of agricultural products as demanded by (4) does present some problems. Effects of general changes in the price level need to be eliminated. In considering the remaining change in the relative price of agricultural goods we have to solve the identification problem of which demand and/or supply surves have shifted. For example, a relative rise in agricultural prices may represent either a greater movement to the right of the demand curve than the supply curve for agricultural goods, a greater move to the right of supply than demand for non-agricultural goods, or some combination of the two.(17)

Not surprisingly, given the data availability for the eighteenth century, this cannot be settled with certainty. However, a plausible estimate

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(17) There are, of course, still further possibilities.

for $\frac{\dot{p}_{ag}}{p_{ag}}$ can be constructed at least for the period 1710-80. This period saw little change in the price index, especially for non-agricultural goods. Since we normally expect fairly little fluctuation in the real price of these goods because long-run elasticities of both supply and demand are high, it will be argued that over long periods such as thirty years $\frac{\dot{p}_{ag}}{p_{ag}}$ can be reliably estimated by the rate of change of the inter-sectoral terms of trade. The later years of the century experienced substantial inflation and war and this procedure is rather doubtful. Accordingly, results reported below for 1780-1800 are subject to a large margin of error. As a measure of $\frac{\dot{p}_{ag}}{p_{ag}}$ the rate of change of wheat/other prices reported in Table 23 of British Economic Growth is used.(18) If agricultural price changes are misrepresented by this method the bias is likely to be small.(19)

Values of the variables for substitution into equation (4), other than n and e, are presented in Table 1 for the periods 1710-40, 1740-80 and 1780-1800. The periodisation attempts to provide reasonably long periods, match Deane and Cole's "two-phase" approach and to demarcate the period of decline of both population and agricultural prices.

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(18) These prices are decadal averages and as such do not represent one atypical year.

(19) The problems come from the treatment of animal products; these should ideally be in the agricultural price index. We have no meat price index comparable to the wheat one. Gilboy comments "The two groups move together quite closely, except for a difference in timing of the upward trend. With cereals the rise begins in the'fifties; with animal products in the late 'thirties." So in terms of decadal averages the use of wheat/other prices may slightly overestimate falls in agricultural prices in the first period and rises in the second. However, since the late 'thirties were apparently a turning point in meat prices, the wheat price series should be acceptable, (taking 1705-15 to 1735-45), for the purpose of measuring price trends over the long periods as defined in the text; this seems to be Gilboy's sentiment. See E. W. Gilboy, "The Cost of Living and Real Wages in Eighteenth Century England, Review of Economic Statistics XVIII (1936), 137.

Table 1

	$\dot{P}_{ag}/P_{ag}$	$\dot{Q}_{ag}/Q_{ag}$	$\dot{I}_{ag}/I_{ag}$	$(\dot{Y/P})/(Y/P)$	$\dot{P}/P$
1710-40	-0.75%	0.00%	-0.02%	0.25%	-0.03%
1740-80	0.56%	0.49%	0.06%	0.34%	0.61%
1780-1800	1.68%	0.65%	0.14%	1.08%	0.98%

Source: Derived from Deane and Cole Tables 17, 19 and 23.
$\dot{I}_{ag}/I_{ag}$ assumed = 0.5 x growth rate of grain imports.

Values for n and e have to be assumed. Evidence of research on income elasticity in low income countries suggests $0.3 < n < 1$.(20) For the test of Deane and Cole we adopt the value of 0.5 chosen by Mellor as appropriate to relatively high income developing countries.(21) Following Mellor we may now infer $e = -0.6$.(22)

The results obtained from the substitution of $n = 0.5$, $e = -0.6$ together with the figures in Table 1 into the right-hand side of equation (4)

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(20) F.A.O., Commodity Review (Special Supplement) (Rome 1962).

(21) Mellor, op.cit. 75.

(22) Ibid. p.75. Mellor arrives at his result, (op.cit. pp. 71-2), from the Slutsky-Schultz relation. This states that the sum of the price elasticity, the income elasticity and the cross elasticities of demand for a good is zero. Mellor makes the common argument that the sum of the cross elasticities of demand for agricultural goods will be small but positive in a low income country and hence the price elasticity will be of the opposite sign and slightly larger than the income elasticity. A proof of the Slutsky-Schultz relation is available in H. and L. J. Wold, Demand Analysis (New York, 1953), Ch. 5.

are reported in Table 2. The clear impression given by Table 2 is that the real output index is not compatible with observed price behaviour, especially prior to 1740. Very similar results are obtained from other plausible values for n.(23)

Table 2

	$\dot{p}_{ag}/p_{ag}$ (act.)	$\dot{p}_{ag}/p_{ag}$ (est.)
1710-40	-0.75%	0.19%
1740-80	0.56%	0.38%
1780-1800	1.68%	1.22%

In order to bring $\frac{\dot{p}_{ag}}{p_{ag}}$ (est.) into line with $\frac{\dot{p}_{ag}}{p_{ag}}$ (act.) it is apparent that it would be necessary to raise the growth of agricultural supply relative to demand in the first period and lower it somewhat thereafter, compared with the estimates embodied in Deane and Cole's real output index. There are a number of ways of doing this. Table 3 presents results of such calculations in which all the Deane and Cole assumptions are still retained except for the constant corn consumption index for agricultural output. In other words the whole burden of adjustment is placed on domestic agricultural production. The solutions were obtained iteratively using equation (4) and taking into account the interaction effect of the impact of agricultural growth on income per head. Because the required change in agricultural output growth is somewhat sensitive to the value of n comparative

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(23) The implications of this use of the Slutsky-Schultz relation is that the permutations of values of n and e are very limited. The choice of alternatives for n within the likely range of, say, 0.3-0.7, (hence e = -0.4 to -0.8), will therefore have almost no impact on the outcome of the test. However, it should be noted that the Deane and Cole index would come almost unscathed from the use of a zero income elasticity with associated values of e very close to zero in each period. The use of n = zero would constitute a special case (nullifying the role of income per head) and is an extreme and most implausible assumption.

calculations using $n = 0.3$, $e = -0.4$ and $n = 0.7$, $e = -0.8$ are also presented. These values for n are thought to be towards the extremes of the likely possibilities.

Table 3

	Deane & Cole			Revised n = 0.5			Revised n = 0.3			Revised n = 0.7		
1710-40	0.22%	0.25%	0.00%	0.53%	0.56%	0.72%	0.35%	0.38%	0.42%	0.70%	0.73%	1.11%
1740-80	0.95%	0.34%	0.49%	0.89%	0.28%	0.36%	0.92%	0.31%	0.42%	0.85%	0.24%	0.27%
1780-1800	2.06%	1.08%	0.65%	1.90%	0.92%	0.29%	1.93%	0.95%	0.35%	1.82%	0.84%	0.10%
	$\frac{\dot{Y}}{Y}$	$\frac{\dot{Y/P}}{Y/P}$	$\frac{\dot{Q}_{ag}}{Q_{ag}}$	$\frac{\dot{Y}}{Y}$	$\frac{\dot{Y/P}}{Y/P}$	$\frac{\dot{Q}_{ag}}{Q_{ag}}$	$\frac{\dot{Y}}{Y}$	$\frac{\dot{Y/P}}{Y/P}$	$\frac{\dot{Q}_{ag}}{Q_{ag}}$	$\frac{\dot{Y}}{Y}$	$\frac{\dot{Y/P}}{Y/P}$	$\frac{\dot{Q}_{ag}}{Q_{ag}}$

Evidently the revisions all show a radically different picture of the eighteenth century, (especially with regard to agriculture), from the one given by Deane and Cole. It is suggested that any one of them is more campatible with observed price behaviour than the real output index of British Economic Growth at least up to 1780. Furthermore none of the new estimates could be rejected out of hand as generating growth rates which are impossible to reconcile with much influential literature on the period.

IV

Considerable caution is required in assessing the implications of Table 3 for the purposes of interpreting growth in the eighteenth century. The new figures are not based on new data, should be regarded with suspicion for the post 1780 period and certainly do not provide precise estimates for agricultural growth.

Alternative ways of bringing rates of growth of supply and demand

for agricultural products to fit price behaviour might be appropriate. For example, it has already been pointed out that Brownlee's population series is open to criticism, it could be that population was falling more rapidly than his series shows prior to 1740 and growing somewhat faster thereafter. Similarly other series in Deane and Cole's index may be in error as Wright has suggested[24] and John has implied.[25]

It must be recognised that the best we can do is to think in terms of a range of estimates for eighteenth century economic growth, interval rather than point estimates. Over long periods of 30 or 40 years the problems of using Brownlee's series may not be very great[26] and the non-agricultural series of Deane and Cole may well be accurate. If so, the revised estimates in Table 3 may be acceptable as interval estimates, with those based on n = 0.5 the "best guess". The key result which is not sensitive to plausible changes in the numbers, is that compared with the Deane and Cole index it is necessary to raise considerably the rate of growth of agricultural supply relative to demand pre 1740. This must imply raising per capita income growth pre 1740, both absolutely and relative to post 1740.[27]

It should be noted that there is a very strong presumption that Deane and Cole have underestimated agricultural output growth prior to 1740, both absolutely and relatively to later years. Errors in the non-agricultural series of the type discussed by Wright and John would tend to lead to a need for rather greater rises in agricultural output growth pre 1740 and reductions

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(24) Wright, loc.cit. pp. 399-401.

(25) John, loc.cit. pp. 31-2.

(26) As is well-known, short run growth rates, as computed, are very sensitive to the types of error indicated earlier, long run rates very much less so.

(27) Since it seems unlikely that income per head growth has been over-estimated by Deane and Cole due to errors in the industry series.

post 1740. Other population series tend to suggest rather more demographic increase pre 1740, not greater declines.(28) Thus the results do somewhat strengthen the John/Jones/Kerridge school of thought's position on English agriculture. However, the figures in Table 3 reflect short term influences, (e.g. climate), and not the trend rate of growth of productive potential.

Several tentative conclusions may now be drawn with regard to the "mechanics" of growth.

(i) None of the revised series changes the picture of growth of per capita income much over the very long run; the "best guess" revision would put average real output at 165 in 1800, (1700 = 100), compared with Deane and Cole's 160. The differences lie in <u>when</u> during the century the growth occurred.

(ii) All the revisions suggest growth in per capita income was slower in mid-century (1740-80) than either before or after. Whilst it is still possible to think of these years as exhibiting acceleration in growth of aggregate output, it seems unlikely that this applies either to agricultural output or per capita income.

(iii) The new estimates also all imply that population growth occurred following an increase in the standard of living and nutritional standards in the early part of the century. For example, thinking of agricultural

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(28) See the estimates reported in B. R. Mitchell and P. Deane, <u>Abstract of British Historical Statistics</u> (Cambridge, 1962); Farr's series is an exception to this generalisation.

output in corn consumption terms if 1700 represents 2.25 quarters/head/year, the revised series show a range of 2.7-2.9 quarters in 1740. McKeown, Brown and Record's hypothesis is at least not refuted.(29)

(iv) The hypothesis of great responsiveness of agricultural output growth to high corn prices seems rather questionable. Thus at least part of the presumed stimulus to English growth from favourable terms of trade for agriculture also seems doubtful.

(v) It is not clear that population growth was generally good for economic growth, at least in per capita terms. The mid-century can indeed be seen as a period when population growth started to erode the rate of growth of per capita income, perhaps considerably so. Maybe the mid eighteenth century should be envisaged as a time when the "Malthusian" threat of a "low-level equilibrium trap" was still important.

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(29) Although their casual and misleading use of wheat statistics, loc.cit. p.352, is not supported. It should be noted that the generally parallel movement of wheat and meat prices implies faster long-run growth of grazing output, which faced greater income elasticities. In the short-run higher income elasticities in a time of rising per capita incomes may partly explain different turning points for prices; see above, footnote 19.