PRICING IN THE TRADE CYCLE

1. How do industrial prices respond to short-run changes in demand? Views about industrial price behaviour have tended to fall into three categories:

(a) Some economists stress the role of competitive forces and argue that prices fall in relation to costs in periods of slack and rise relatively in periods of expansion (though different authors may adopt somewhat different definitions of "cost"). This view has been generally confirmed by studies for the United States, particularly where unconcentrated industries are concerned.2

(b) A second theory is that prices rise in relation to costs as demand falls, and vice versa.3 The rise occurs as firms attempt to regain their target profit rate by raising prices. This response, for which there is some scattered evidence,4 is held to occur mainly in concentrated industries.

(c) A third view is that prices move with normal cost, i.e., they do not react to temporary changes in demand or costs; this is the "normal price hypothesis." Although there are several versions of this hypothesis, the common feature is that prices move with long-run costs, and do not change because of variations in demand or cost which are thought to be temporary.5

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1 The authors are very grateful for comments from W. B. Reddaway, L. A. Dicks-Mireaux, F. H. Hahn, R. R. Neild, C. T. Taylor and M. H. Pearse and for research assistance which is acknowledged postscript. The S.S.C.R. have financed part of this work, and are financing the whole of its next stage.


5 For the earliest formal statement of this theory, see Michal Kalecki, Essays in the Theory of Economic Fluctuations, 1939. One of the most influential versions of normal pricing was the theory No. 327.—vol. 82. 853
2. The present paper takes the third view—the normal price hypothesis—\( \text{to be correct and tests for its conformity with recent experience. Our approach was to specify a set of assumptions embodying the essential elements of the hypothesis in a way which made it possible to construct a "prediction" of output prices without any reference to the actual recorded movement of these prices.} \) This prediction was then brutally confronted with the actual movement of prices. Our hope was that the confrontation would provide evidence as to the relative merit of the three views outlined above.

3. The coverage of this inquiry is U.K. manufacturing, excluding food, drink and tobacco. The data, which are remarkably good and well suited to the purpose in hand, are described briefly in the Appendix, but it should be noted in the preliminary exposition that the price indices of sales and purchases are all free of duplication; “sales” are sales by manufacturing industry to buyers outside that sector, while “purchases” of materials and services are purchases from outside the sector. Export sales are excluded from the study partly because of the difficulty of obtaining the necessary data but also because there have been periods (notably that following the devaluation of sterling in the autumn of 1967) when a theory that made changes in export prices solely dependent on costs and real demand would clearly be inappropriate. The food, drink and tobacco group of industries was excluded, mainly because price changes are heavily influenced by changes in indirect tax rates.

4. Our hypothesis is that price is based on normal cost. In order to make this general hypothesis suitable for empirical testing, we must specify it in much more precise terms. First, the normal value of a variable is defined as the value that variable would take, other things equal, if output were on its trend path.

A considerable part of this study is involved in estimating normal values for variables. Second, of the several possible variants of the normal price hypothesis, we have chosen the following for the purpose of constructing the prediction: output price is set by taking a constant percentage over average normal historical current cost. This formulation of the hypothesis enabled us to construct the predicted price series in the following way:


1 To avoid endless repetition, where no issues are at stake, we will employ the short-hand expression “manufacturing” to refer to manufacturing excluding food, drink and tobacco.

2 The trend path, defining normal output, is the prediction of a regression of the logarithm of output against time.
(a) Quarterly series were obtained for the period 1953–1969 for all the components which make up current unit costs—labour (including salaries), materials, fuel, services and indirect taxes. Capital costs and taxes on profits were omitted.

(b) "Normal" unit costs were obtained by purging the relevant series of reversible cyclical components. We removed from average earnings the effect of cyclical changes in hours. In addition, we removed from employment the effect of cyclical changes in output in order to derive normal or trend productivity. Normal labour costs thus consist of an estimate of what average labour costs would have been along a trend growth path of output given the movement of hourly wage rates.

(c) We assume firms use historical cost pricing, with the cost base equal to the sum of costs of different inputs, the cost of each category calculated at time of purchase. As we shall show, the assumption that prices are marked up on historical costs completely determines the distributed lag between cost and price changes. By inference from the cost structure of each industry group, from the pattern of industry sales and from the size of individual and aggregate stock/output ratios, quantitative estimates of the time lag profiles were derived.

(d) Prices were then predicted by simply imposing on each cost the distributed lag for that item and adding them up using weights derived from the cost structure of manufacturing industry in 1963.

5. It must be stressed that the assumptions on which the prediction is based do not correspond completely to the authors’ views of industrial price behaviour. We know, for example, that the markup on cost has declined considerably over the decade of the 'sixties. We also have reservations about the omission of capital costs and the extreme assumption relating to historical cost pricing. Despite these reservations, we do not think that any of the assumptions or procedures would contaminate the prediction by introducing a bogus cyclical element, or by removing a genuine association between the markup and demand. We recognise that further tests could show this to be wrong. Because the tests presented in this article leave many such questions unanswered, we plan to test the validity of our assumptions in a monograph. This further work will contain a fuller account of the data, a critical survey of the existing literature on the subject and the results of further experiments relating to disaggregated data, the lag structure, tax shifting and incomes policy.

1 Earlier studies, so far as we know, have only taken account of the pay of manual workers and of the cost of materials and fuel, which only account for about 60% of current costs.

2 It could be argued that firms sometimes consider changes in the cost of bought-in materials to be cyclical—or at least temporary—and therefore that these series should be "purged" just as much as labour costs. The only period when there was a serious possibility that changes in input prices were considered temporary is that following the Suez crisis in 1956–57. The change does not seem to have been quantitatively large, however, and we have ignored the problem.
THE DERIVATION OF NORMAL OR "TREND" COSTS

6. Our first task was to construct a series measuring average weekly earnings (corrected for cyclical changes in overtime) divided by normal productivity. The first three sections below deal with hours, earnings and employment, while the last discusses other costs.

A. Hours

7. Our hypothesis is that average hours will change mainly because of changes in output and standard hours. There may, however, be long-term trends unrelated to either of these factors; for instance, there has been a tendency for the number of women working part time to rise relatively fast, and this may have reduced average hours worked over the years. In addition, it is possible that hours can be adjusted more rapidly than employment in response to changes in output, causing an over-reaction in the initial response of hours which is reversed as employment subsequently adjusts.

This hypothesis may be written

\[ H^\ast = a_0 + a_1 HS + a_2 CU + a_3 t + \epsilon \]  \hspace{1cm} (1)

where \( H^\ast \) = desired (or adjusted) hours per week, \( HS \) = standard hours per week, \( CU \) = the degree of capacity utilisation, current and lagged, \( t \) = a time trend and \( \epsilon \) is the unexplained residual. The preferred econometric results are presented in Table I below.

8. We only give here a scantly record of our negative results. We tested for the presence of a first order partial adjustment mechanism by including a lagged dependent variable term. The coefficients were insignificant and carried a negative sign. A number of experiments were carried out to establish the lag structures on capacity utilisation. The adjustment pattern for men showed no significant lag after the current period. For women the first lagged term was highly significant and indicated the initial over-reaction which we anticipated; we preferred to include two lagged terms on grounds of plausibility although the second has an insignificant coefficient. The equations were tested in first differences, but for both men and women there was a deterioration in the standard error of estimate and negative auto-correlation of residuals was introduced. There was no evidence of a lag in the adjustment of actual to standard hours.

9. We now define customary hours, \( HC \), as desired hours at a normal level of output, where the hats denote estimated values of coefficients.

\[ HC = \hat{a}_0 + \hat{a}_1 HS + \hat{a}_3 t \]  \hspace{1cm} (1c)

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1 We are not using the official terminology, which causes confusion in discussing the normal price hypothesis. In the U.K. official statistics, the term "normal hours" refers to the basic or standard working week determined by law or national negotiations. We call this standard hours. "Customary hours" are used in this paper to mean the number of hours worked when output is at its normal or trend level. Actual hours cycle around "customary hours;" for men customary hours are on average above standard hours, for women they are below.
TABLE I
Preferred Equations for Hours, 1953–1969

\[ H = 20.1 + 0.636 \text{ HS} + 12.51 \text{ CU} \]
\[ (25.7) \quad (35.3) \quad (11.27) \]
\[ R^2 = 0.974 \quad \text{SEE} = 0.168 \quad dw = 1.59 \quad \overline{DV} = 47.0 \]

**Women**

\[ H = 17.0 + 0.537 \text{ HS} + 2.69 \text{ CU} - 4.93 \text{ CU}_{-1} - 1.78 \text{ CU}_{-2} - 0.042t \]
\[ (0.3) \quad (1.2) \quad (4.7) \quad (2.2) \quad (1.16) \quad (0.23) \]
\[ R^2 = 0.991 \quad \text{SEE} = 0.125 \quad dw = 1.814 \quad \overline{DV} = 40.0 \]

**Notes on statistical terms for Table I and subsequent Tables**

- \( R^2 \) is the multiple correlation coefficient corrected for loss of degrees of freedom. \( \text{SEE} \) is the standard error of estimate of the equation. \( dw \) is the Durbin-Watson statistic. \( \overline{DV} \) is the mean of the dependent variable. Figures in square brackets here and throughout the article refer to the absolute value of \( t \) ratios. \( \text{CU} \) is a measure of deviation of actual from trend output (see Appendix paragraph 9). Other definitions and derivations of data are given in the Appendix.

**B. Earnings**

10. Our hypothesis is that the main factors determining average weekly earnings (AWE) which can be directly measured or inferred are basic hourly wage rates\(^1\) (BHR), the number of hours worked (H) and the size of the overtime premium. In addition, there are other factors—such as the effect of local plant bargaining on differentials, bonuses, etc., and changes in the skill distribution of workers—for which we do not have data but which are important in determining both the level and the rate of growth of earnings. It is well known that earnings over the long term have risen substantially faster than nationally negotiated rates.

11. The earnings hypothesis may be built up as follows. First suppose that overtime and standard hours are all paid at the same rate and that there are no payments other than nationally negotiated minima and no changes in the skill mix. We could then formulate the earnings relationship:

\[ \text{AWE} = BHR^{b_1} H^{b_2} \]

with the expectation that the exponents \( b_1 \) and \( b_2 \) would both equal unity.

12. The hypothesis is next modified to allow for the existence of an overtime premium and for other payments in excess of basic rates. A coefficient on overtime hours (\( H - \text{HS} \)) is introduced into the expression in square brackets. A further coefficient is also introduced to allow for earnings drift; the best we have been able to do is to assume this is an exponential time trend. The full hypothesis may now be written:

\[ \text{AWE} = c_0 + c_1 BHR^{b_2} [H + b_3 (H - \text{HS})]^{b_4} \]

\( ^1 \) The index of wage rates measures changes in nationally negotiated (or statutory) minimum wage rates.
13. In (2a), the coefficient $b_2$ represents the proportional impact of basic hourly rates on earnings; there are grounds for expecting its value to be less than unity mainly because the index measures only minimum rates of pay but also because the wage settlement may contain a certain amount of de jure consolidation of earlier de facto gains in earnings. The coefficient $b_3$ represents the proportional effect of hours on earnings. As in the case of $b_2$, there are grounds for expecting $b_3$ to have a value less than unity, the most important being that a proportion of earnings takes the form of supplements which are insensitive to changes in hours. Finally, $b_4$ represents the overtime premium, so that $HS + b_4 (H - HS)$ measures actual hours in terms of standard-hour-equivalent units.¹

14. As equation (2a) is nonlinear in logarithms, we used the following approximation procedure. Taking logarithms of (2a) we have

$$\ln AWE = b_0 + b_1 t + b_2 \ln BHR + b_3 \ln [HS + b_4 (H - HS)] + \epsilon$$

Rewriting the term in brackets as $[HS (1 + b_4 (H - HS) / HS)]$ and taking logarithms of this term yields:

$$\ln AWE = b_0 + b_1 t + b_2 \ln BHR + b_3 \ln HS + b_4 \ln [1 + b_4 \frac{H - HS}{HS}] + \epsilon$$

Using the first order Taylor expansion, we obtain our final estimating equation:

$$\ln AWE = b_0 + b_1 t + b_2 \ln BHR + b_3 \ln HS + b_4 \frac{H - HS}{HS} + \epsilon \quad (2b)$$

15. The following Table shows the preferred regression estimates for equation (2b).

**Table II**  
**Preferred Equations for Earnings, 1953–1969**

<table>
<thead>
<tr>
<th>Men</th>
<th>$\Delta \ln AWE = 0.0107 + 0.7592 \Delta \ln BHR + 0.6032 \Delta \ln HS + 0.1025 \frac{H - HS}{HS} \quad (2c)$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$[4.73] \quad [9.45] \quad [2.71] \quad [7.45]$</td>
</tr>
<tr>
<td></td>
<td>$R^2 = 0.785 \quad SE = 0.0068 \quad dw = 1.59 \quad DY = 0.0293$</td>
</tr>
</tbody>
</table>

| Women | $\Delta \ln AWE = 0.0122 + 0.6122 \Delta \ln BHR + 0.5079 \Delta \ln HS + 0.0427 \frac{H - HS}{HS} \quad (2d)$ |
|       |-------------------------------------------------------------------------------------------------|
|       | $[4.88] \quad [6.15] \quad [2.11] \quad [3.70]$                                               |
|       | $R^2 = 0.566 \quad SE = 0.0059 \quad dw = 1.43 \quad DY = 0.0265$                            |

**Notes:** The notes attached to Table I apply to this table as well.

¹ The D.E.P. publishes estimates of average hourly earnings corrected for overtime implicitly using the formula in (2a), with coefficients $b_4 = 1$, $b_3 = 1$, and $b_2 = 1.5$. The regression coefficients presented here provide a significant improvement over the D.E.P. coefficients. Neild and others have employed the D.E.P. correction in normalising earnings, so the cyclical effect was not sufficiently removed.
16. These results seem satisfactory and accord well with our *a priori* expectations. The coefficient of the basic hourly wage rate \( b_3 \) confirms the hypothesis that there is a smaller than proportional response of earnings to basic rates. For men, the response is about 76\%, which is 3.0 standard errors less than unity;\(^1\) for women, the response is 61\%, which is 3.9 standard errors less than unity.\(^2\) The coefficient \( b_3 \) also accords well with *a priori* specification, but is less well determined; it should be noted that this coefficient refers to the elasticity of earnings, not with respect to standard hours, but with respect to actual hours measured in standard hour equivalent units. The coefficients are 1.8 and 2.0 standard errors smaller than unity, both of which are significant at the 95\% level.\(^3\)

17. The coefficient \( b_1 \) implies an average annual rate of earnings drift of 2–2.4\% both for men and for women. Finally, the estimated overtime premia \( (b_4) \)\(^4\)–1.83 for men and 1.66 for women—also lie within the expected range. The lower coefficient for women can be explained by the fact that a much larger fraction of women than of men are working part time; indeed, average actual hours worked by women are lower than standard hours.

18. We can now define and produce estimated series for normal earnings (AWEN) by substituting "customary hours" HC for H.

\[
\ln \text{AWEN} = b_0 + b_1 t + b_2 \ln \text{BHR} + b_3 \ln \text{HS} + b_4 \frac{(\text{HC} - \text{HS})}{\text{HS}} \tag{2e}
\]

The "normalised" series were constructed using the observed values of earnings per head in 1963 as our base year.

C. Productivity and Employment

19. As for hours and earnings, we need again to separate "normal" from cyclical productivity. The employment series was split into operatives on the one hand, and administrative, technical and clerical workers (A.T.C.s) on the other. For both operatives \( (L_{op}) \) and A.T.C.s \( (L_{ATC}) \) a quarterly index of "male-equivalent" employment was constructed by weighting males and females in proportion to their weekly earnings.

\(^1\) While the coefficient implies that a 4\% rise in basic rates will lead to a 3\% rise in earnings, the cash increase in earnings will usually nevertheless be larger absolutely than in basic rates.

\(^2\) Using conventional tests, both these coefficients are significantly less than one at the 99.5\% confidence level. It should be noted, however, that the coefficient \( (b_4) \) is sensitive to the assumption about the error specification for women. The tests are conditional on the assumption about the first-order correlation of the errors. An unconditional test for women would probably prove insignificant.

\(^3\) However, the reservation concerning the errors discussed in the previous footnote applies with equal force here.

\(^4\) \( b_4 \) is obtained by dividing the coefficient on \( \frac{\text{HC} - \text{HS}}{\text{HS}} \) by that on \( \ln \text{HS} \).
20. Our hypothesis may be written  

\[ L^* = \delta_0 + \delta_1 X + HC_{prev} \]  

(3)

where \( L^* \) = desired (or adjusted) employment and \( X \) = output.

21. In the econometric testing, a lagged dependent variable was useless in view of the high serial correlation of the employment series, and individual quarterly lagged values for \( X \) always took on very poorly determined coefficients. We therefore carried out a number of experiments using imposed lags of varying length. Table III shows the preferred regression results for the period 1954–69.

**Table III**

*Productivity and Employment*

<table>
<thead>
<tr>
<th>Operatives</th>
<th>( \Delta \ln L_{op} = -0.496\Delta \ln X' + 0.770\Delta \ln HC' - 0.00433 - 0.000012t )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[12.15] [2.96] [5.42] [3.00] []</td>
</tr>
<tr>
<td></td>
<td>( R^2 = 0.747 ) ( \text{SEE} = 0.0025 ) ( dw = 1.05 )</td>
</tr>
<tr>
<td>A.T.C.s</td>
<td>( \Delta \ln L_{ATC} = -0.223\Delta \ln X'' + 0.00749 - 0.00005t )</td>
</tr>
<tr>
<td></td>
<td>[1.99] [3.71] [2.02] []</td>
</tr>
<tr>
<td></td>
<td>( R^2 = 0.100 ) ( \text{SEE} = 0.0065 ) ( dw = 2.20 )</td>
</tr>
</tbody>
</table>

**Notes:**

\( hX' \) is defined for operatives as:

\[ 0.286hX + 0.238hX_{-1} + 0.190hX_{-2} + 0.143hX_{-3} + 0.095hX_{-4} + 0.048hX_{-5} \]

and for A.T.C.s \( hX'' \) is:

\[ 0.222hX + 0.194hX_{-1} + 0.167hX_{-2} + 0.139hX_{-3} + 0.111hX_{-4} + 0.083hX_{-5} + 0.056hX_{-6} + 0.028hX_{-7} \]

\( \ln HC' \) is defined as \( 0.40\ln HC + 0.30\ln HC_{-1} + 0.20\ln HC_{-2} + 0.10\ln HC_{-3} \)

22. These results indicate, so far as operatives are concerned, an elasticity in the response of employment to changes in output of about \( \frac{1}{4} \), and an elasticity of about \( -\frac{3}{4} \) in the response to changes in customary hours. The equations cannot, however, be regarded as being satisfactory since significant serial correlation of residuals persists even in our preferred equation. The standard error of estimate was slightly reduced if a lag of eight quarters was imposed, and, when fitted in first differences, the coefficient on \( HC \) lost its significance. We prefer the equation shown because a lag of eight quarters seems implausibly long for manual operatives.

23. The index of A.T.C. employment over this period is of some interest in itself, showing a sustained increase at a rate far larger than that of operatives. Casual inspection of this series, moreover, suggests that no significant changes occurred in response to output. It seemed possible that part of

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1 An extended discussion and derivation of this function will be presented in the forthcoming monograph.
the reason for the relative increase in the A.T.C. employment series was that there was a progressive reclassification of employees into supervisory or "white collar" categories. It was only when a relatively long lag—eight quarters—was imposed on the output series that the latter took on a significant coefficient, and a relatively long adjustment process seems acceptable for this group of employees. The constant and coefficient on time sum to a significant positive total, indicating an increasing usage of A.T.C.s per unit of output. The implicit negative productivity trend for A.T.C.s, if it stems from a process of substitution or reclassification of white for blue collar workers, indicates that it is quite wrong to draw conclusions about productivity from consideration of manual workers alone.

24. We can now define "normal" operative employment \((L_{op}N)\):

\[
\ln L_{op}N = \hat{c}_0 + \hat{c}_1 \ln XN + \hat{c}_2 \ln HC + \hat{c}_3 t + \hat{c}_4 t^2
\]  

(3c)

where the \(\hat{c}_t\) are coefficients estimated in equation (3a).

We can finally define normal operative earnings at normal output per normal head as:

\[
ULCN_{op} = \frac{AWEN \cdot L_{op}N}{XN}
\]  

(4)

Similarly we define trend employment of A.T.C.s:

\[
\ln L_{ATC}N = \hat{c}_0' + \hat{c}_1' \ln XN + \hat{c}_2' t + \hat{c}_3' t^2
\]  

(5)

and normal unit A.T.C. costs:

\[
ULCN_{ATC} = \frac{S \cdot L_{ATC}N}{XN}
\]  

(6)

where \(S\) is defined as salaries per head.

We can be confident that all reversible cyclical effects have been purged from these series; the only variables entering normal costs are basic weekly rates, standard hours, salaries per head, and time.

25. Normal unit labour costs were calculated as indicated by the definitions of equations (4) and (6) above and employers' contributions (obtained by dividing contributions per head by normal output) were added in.

D. Derivation of the Other Cost Series

26. Other (i.e., non-labour) costs consist of materials, fuel, services and indirect taxes paid by manufacturers. For the cost of materials and fuel our figure was derived from the monthly series published by the D.T.I. The cost of bought-in services such as transport and distribution was derived from the data bank of the Cambridge growth project.1 In taking these various cost indices we are implicitly assuming that the volume of materials

1 These data, though themselves unpublished, are derived from published material such as the accounts of the nationalised transport undertakings. The authors are grateful to Mr. Vivian Woodward for making them available.
and services used per unit of output remains constant. We have grounds for supposing this assumption to have been approximately correct; changes in the value of purchases by manufacturing industry between 1954 and 1968 for both materials and services shown in the published input-output tables agree in each case quite closely with the change in output times the change in the price of input.  

27. The decision as to whether a given tax or subsidy should be included was not always easy. There were no conceptual difficulties about ad valorem indirect taxes (such as petrol taxes or protective duties) because these are clearly current normal unit costs. At the other end of the spectrum, taxes on corporate profits do not enter long-run average cost of production and were excluded. Difficult choices arose in the cases of the Selective Employment Premium (S.E.P.) and the Regional Employment Premium (R.E.P.) which were excluded by a flip of a coin. It will be one of the most important objectives of the next phase of our study to see whether these assumptions regarding tax shifting are warranted.

TIME LAGS BETWEEN COST AND PRICE CHANGES

28. Within the framework of the normal pricing hypothesis one natural assumption to make is that firms fix their prices as a constant markup on normal historical costs. This assumption is based partly on the widespread practice of valuing stocks at cost on a FIFO basis; it has the particular advantage of enabling us to produce, by direct reference to facts, quantitative estimates of the lag structure which can then be imposed on the constructed cost series without any fitting procedure.

29. Our way of estimating time lags can be outlined thus. Imagine a firm A which buys and sells commodities without processing them at all, as in the ageing of a fine old wine. The firm sells goods in the order in which it buys them, and the average length of time between purchase and sale—its “production period”—is denoted by $\theta$. Time throughout refers to quarters. If the firm practises historical cost pricing, a step rise of $x\%$ in costs in one quarter will result in a step change of $x\%$ in selling prices after a period exactly equal to $\theta$ quarters. We next imagine another firm B which buys nothing in the way of materials, its sales consisting entirely of its own value added; production might, for instance, consist of digging coal and turning it into coke, so $\theta$ would be the time between the extraction of a lump from the coal face and its sale as coke. If we assume that value is added evenly throughout the production period, then a step rise of $x\%$ in labour costs would result, with historical cost pricing, in a price rise of $x\%$ after the first and each subsequent quarter until one whole production period has elapsed.

30. To be more realistic, we hypothesise that production by a typical

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1 See Appendix, particularly Table A-1.
firm C will combine elements of the processes imagined in each of these simple examples. In other words, a proportion of materials will enter at the beginning of the productive process, and other materials, fuel and the firm's own value will be added throughout the rest of it. To the extent that

\[ \text{Firm A's "production" run} \]

\[ \text{Fig. 1} \]

materials enter throughout the productive process, a step increase of \( x\% \) in their cost will feed through into prices in exactly the same way as do labour costs, \( i.e. \), price will rise \( \frac{x}{\theta}\% \) (times the proportion of these materials in total costs) per quarter until \( \theta \) quarters have elapsed.

31. Now, we can estimate, for a single firm, the value of \( \theta \) from its stock-output ratio, provided we know the cost composition of its sales and the

\[ \text{Production process for Firm B} \]

\[ \text{Fig. 2} \]

fraction of bought-in materials which enter the productive process at its start, and provided that all inputs other than materials entering at the beginning of the process are added evenly throughout it.\(^1\) The method may be represented graphically in Fig 1.

In Fig. 1 the area \( abcd \) represents Firm A's stocks, \( pqr \) its quarterly sales. In this simplest case the production period \( \theta \) is given by the level of stocks divided by quarterly sales, \( i.e. \), \( \theta = \frac{abcd}{pqr} \).

In the case of firm B stocks are represented in Fig. 2 by the triangle \( abn \)

\(^1\) The term "stocks" is used throughout to mean "stocks and work in progress." The "productive process" in this system starts at the point materials are purchased and are included in the figures for stocks.
and weekly sales by \( pqe \). In this case \( \theta \) is twice the stock-output ratio. The point is made obvious if one imagines Firms A and B as both having the same quarterly value of sales and the same production period; then since work in progress held by B will on average be only half completed, B's stocks will be worth half those of A's.

32. We assume firm C represented in Fig. 3 to be fairly realistic. In this

![Production run for Firm C](image)

Fig. 3

Diagram \( abed \) represents stocks of materials which enter at the beginning of process, and \( dcn \) is stocks consisting of all the cost and profit components which are added progressively throughout it. The area \( dcn \) has been subdivided into \( dem \) (materials other than \( abed \)), and \( dmn \) (all other cost components and profits). Now let:

- Total stocks = \( S = abnd \).
- Quarterly sales = \( X = pqe \).

Since \( pq = 1 \), \( X = pe = bn \).

- Share of materials in sales = \( \alpha = \frac{bm}{bn} \).
- Share of materials entering at the beginning = \( \beta = \frac{bc}{bm} \).
Since \( S = \theta \cdot bc + \frac{1}{2} \theta \cdot cn \)

\[
\theta = \frac{bc + \frac{1}{2}(X - bc)}{2S}
\]

\[= \frac{X(1 + \alpha \beta)}{X(1 + \alpha \beta)}
\]

33. For manufacturing industry as a whole and for individual industries we can in Census years observe \( S, X \) and \( \alpha \). So far as \( \beta \) is concerned we have assumed—and this is the one major arbitrary assumption necessary—that two thirds of materials enter at the beginning of the process, the remaining one third and all fuel being added progressively throughout. In addition it was necessary to assume that for all of the cost categories (i.e., labour, fuel, materials, etc.), every component price *within* each category moves together.

34. The detailed derivation of the numerical lag structure is rather tedious and has therefore been banished to the Appendix. At this point we limit the description to the barest essentials. We first calculated the period of production for the main industry groups of manufacturing using the method outlined in paragraphs 32–33 above. If there were no inter-industry flows and all sales went outside manufacturing, we could stop here and calculate the lag structure. We take into account that some sales recycle within manufacturing by constructing a simple input–output system with five manufacturing sectors. The flow of an input is then traced through manufacturing until it all emerges in the form of sales outside manufacturing; at every point of exit, the appropriate change in price of output will occur.

35. To get our final distributed lag, we determine the fraction of each broad input category which exits during each subsequent quarter. These distributed lags are shown in Table IV.

**Table IV**

<table>
<thead>
<tr>
<th>Cost item</th>
<th>Distributed lag (in quarters) of price behind cost.</th>
<th>Total.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Materials</td>
<td>0.075</td>
<td>0.311</td>
</tr>
<tr>
<td>Other inputs</td>
<td>0.213</td>
<td>0.365</td>
</tr>
</tbody>
</table>

**The Behaviour of Predicted Prices**

36. Having constructed comprehensive cost series, we can construct a series for *predicted price*. The definition of predicted price is

\[
P_t = \left( \frac{1963}{\text{mark-up}} \right) \times \left( \frac{\text{Historical}}{\text{normal unit}} \right)_{t}
\]
The "1963 mark-up" is the ratio of total value of output in 1963 to total historical normal current cost in 1963. "Historical normal unit cost" is the sum of the lagged components of cost, where the components are estimated unit costs when output equals normal output. The actual and calculated prices are shown in Figs. 4 and 5 for quarterly percentage changes and levels. The most striking fact is that the mark-up of price over normal costs has fallen over the period, especially since 1961. Aside from this discrepancy, the movement in predicted price resembles actual price surprisingly well, given that the predicted price series is constructed without any reference to actual prices at all.

37. Before moving to a test of the normal pricing hypothesis, we first discuss the movement of profits over the period examined. The profits counterpart of the normal pricing hypothesis is that normal gross profits (that is, profits at normal output, employment, etc.) should be a constant fraction of total value of sales. If this theory of profits were precisely correct, the ratio of predicted price to actual price would remain constant. In fact external evidence shows that profit margins have declined substantially over the period.

38. Although there are many possible causes for the falling rate of profit we can at this point rule out several. It is not because of the acceleration in cost inflation which temporarily reduces profit margins as prices lag behind costs; we have accounted for this possibility by the historical cost lag. Nor is this simply a statistical fiction caused by measuring profits as a fraction of domestic value added rather than total sales, for we have taken account of all costs. We can also rule out the possibility that profits are measured with large error. Successive input/output tables for 1954, 1963 and 1968 show a decline in profits as a percentage of gross output from 19.9% in 1954, to 17.1% in 1963 and again to 14.7% in 1968;¹ this decline is sufficient to account for the cumulative divergence between our calculated and actual values. Although we cannot choose between competing explanations at this time, we pose the following possibilities for further testing.

(a) Inclusion of other costs. The definition of cost used here includes only current costs, but an alternative hypothesis² is that prices are marked up on full costs. If other items are included—for instance S.E.P., R.E.P., and taxes on profits—the cost base will grow more slowly, especially over the second half of the period.

(b) Competition. A second possibility is that competitive forces are operating, one way or another, progressively to drive down the normal profitability of industry. For instance, it is clear that imports of competing manufactured products have gained an increasing share of the U.K. market over the period in question. If this share was gained by price competition, the profitability of these competing industries would fall over the period. On

¹ See Appendix Table A-1.
² See Eckstein and Fromm, op. cit., and Diriam et al., op. cit.
Actual and "Predicted" prices 1955-1969

(a) Percentage changes quarterly

Fig. 4
the other hand, the devaluation of November 1967 should have reversed this phenomenon, a reversal not apparent by the end of 1969.

39. Other considerations. Other factors which will be considered are the role of nationalisation of steel and the effect of incomes policies.

E. Testing the Normal Price Hypothesis

39. We are now prepared to present formal tests of the normal price hypothesis—the formal definition of this now being:

the mark-up of price over normal historical current average cost is independent of the conditions of demand in the factor and product markets and is independent of the deviations of actual cost from normal cost.

We recognise the limited scope of this hypothesis in view of our inability at this stage to explain the secular decline in profit margins. Because the normal price hypothesis does not explain prices perfectly, there is clearly room for alternative tests and explanations. At this stage we have limited ourselves to testing the hypothesis by looking to see if residual movements in price after taking out the predicted effect of normal pricing have a systematic cyclical pattern. To test for cyclical patterns, we have constructed several measures of the state of demand in product and factor markets. We then test the normal pricing hypothesis by regressions of price on predicted price and cyclical variables. The latter fall into two categories, product market variables and labour market variables and are shown in Table V.1

40. We first set out what was our a priori preferred test of the normal price hypothesis. This test uses our constructed measure of capacity utilisation \( X_4 \) and assumes that the mark-up on historical cost rises as a linear function of this demand variable. A logarithmic specification is chosen to reduce heteroscedasticity. It seems best to test this equation in first differences because of evident serial correlation of the residual between predicted and actual price. The result of this preferred test is the following:

\[
\Delta \ln P_t = 0.001399 + 0.6248 \Delta \ln \hat{P}_t + 0.000238 \Delta \ln (X/XN)_t
\]

\[
[1.42] \quad [5.36] \quad [0.66]
\]

\[
R^2 = 0.340 \quad SE = 0.00403 \quad d.w. = 1.83 \quad D\bar{V} = 0.0059
\]

where \( \hat{P} \) is predicted price.

The preferred regression indicates that our predicted price series is reasonably successful in predicting the actual movement in prices. The Durbin–Watson indicates no further serial correlation after first order correlation is removed. The disturbing features are the positive intercept and the fact that the coefficient on predicted price is significantly less than

1 There is an arbitrary question whether \( L_2, L_3, L_4 \) and \( L_5 \) are labour market variables. We call them such because they depend primarily on labour market data for the calculation of capacity.
unity. The most important fact is that the coefficient on the demand variable is insignificant and very small indeed. If we use the estimated standard error of the coefficient we can rule out with 99% confidence an elasticity of price with respect to utilisation of more than 0.01 in absolute value.

**Table V**

Cyclical Variables Used in Tests

<table>
<thead>
<tr>
<th>Name.</th>
<th>Description.</th>
<th>Source.</th>
<th>Sample.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X_1$</td>
<td>Deviation of In output from prediction of logarithmic regression of output on time, non-farm manufacturing.</td>
<td>Godley-Nordhaus</td>
<td>entire</td>
</tr>
<tr>
<td>$X_2$, $X_3$</td>
<td>Ratio of output to &quot;capacity&quot; using Wharton School techniques.</td>
<td>Briscoe, O'Brien, Smyth*</td>
<td>1956-I to 1967-IV</td>
</tr>
</tbody>
</table>

**Factor Market**

<table>
<thead>
<tr>
<th>Name.</th>
<th>Description.</th>
<th>Source.</th>
<th>Sample.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_1$</td>
<td>&quot;Excess demand for labour&quot; given by the difference between the vacancy rate and the unemployment rate, manufacturing.</td>
<td>Neild †</td>
<td>1949-III to 1960-IV</td>
</tr>
<tr>
<td>$L_1$, $L_2$</td>
<td>&quot;Capacity multiplier indices&quot; based on unemployment rate for manufacturing.</td>
<td>Briscoe, O'Brien, Smyth ‡</td>
<td>1954-I to 1964-IV</td>
</tr>
<tr>
<td>$L_4$, $L_5$</td>
<td>&quot;Production Function Indices&quot; based on full employment labour supply to manufacturing.</td>
<td>Briscoe, O'Brien, Smyth §</td>
<td>1967-IV</td>
</tr>
<tr>
<td>$L_6$</td>
<td>Unemployment Rate, manufacturing.¶</td>
<td>Briscoe, O'Brien, Smyth</td>
<td></td>
</tr>
<tr>
<td>$L_7$</td>
<td>Inverse of Unemployment Rate, manufacturing.</td>
<td>Historical Abstract **</td>
<td>entire</td>
</tr>
</tbody>
</table>

* G. Briscoe, P. O'Brien, D. J. Smyth, "Measurement of Capacity Utilization," *The Manchester School*, June 1970, No. 2, pp. 91-117; Table 1B. $X_1$ is series $W_i$, $X_2$ is series $W_i$.

† Neild, op. cit., p. 69.
‡ Briscoe, et al., op. cit., Table 2B. $L_2$ series is M1, $L_2$ series is M11.
§ Ibid., Table 3A. $L_4$ series is $\rho_1$, $L_4$ series is $\rho_1$.
¶ Ibid., Table 2B.

To preserve the pro-cyclical correlation of demand variables, $L_6$ was entered with a negative sign.

** D.E.P., Historical Abstract of Labour Statistics, Table 131. This is the ratio of unemployment to (unemployment plus employees in employment).

41. We recognise that our preference for testing the normal price hypothesis may not be shared and that there is a very large number of ways that demand can interact with cost in price determination. In order to allow for differences in taste, we have conducted a battery of tests using all combinations of ten demand variables and ten different functional specifications. The specifications comprise equations in levels and first differences, in linear and logarithmic forms, and with and without first order adjustment of prices.

1 The coefficient on predicted price is somewhat a puzzle. Our tentative hypothesis is that it is reduced below its assumed correct value of unity (a) because of incorrect lag estimates which mean, in effect, that $\hat{P}$ is measured with error and (b) because of special factors in the second half of the period—in particular incomes policy, nationalisation of steel, and devaluation—which threw price from its normal relation. A glance at Fig. 5 shows that actual and predicted price move very closely up to about 1963, after which the forces mentioned above seem to disturb the pattern.
42. We clearly cannot present the complete set of results for the 100 tested combinations. As we are primarily interested in tests of the normal price hypothesis, we will present only the calculated t-statistics for the demand variable in each equation. These statistics are shown in Table VI, along with the detailed variables and specifications.

43. Table VI indicates that 4 of the 100 coefficients are “significant” at the 10% level. If the demand variables were stationary independent series randomly chosen, we would expect 10 coefficients to be “significant.” By this (strictly informal) test, the hypothesis that demand affects price appears to do worse than random.

**Table VI**

*Menu of t-Statistics for Demand Variables in Price Equations*

<table>
<thead>
<tr>
<th>Demand variables</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( S_1 )</td>
</tr>
<tr>
<td>( X_1 )</td>
<td>-1.207</td>
</tr>
<tr>
<td>( X_2 )</td>
<td>2.190</td>
</tr>
<tr>
<td>( F_1 )</td>
<td>1.446</td>
</tr>
<tr>
<td>( F_2 )</td>
<td>1.958</td>
</tr>
<tr>
<td>( F_3 )</td>
<td>-1.238</td>
</tr>
<tr>
<td>( F_4 )</td>
<td>-1.215</td>
</tr>
<tr>
<td>( F_5 )</td>
<td>-2.729</td>
</tr>
<tr>
<td>( F_6 )</td>
<td>-2.401</td>
</tr>
<tr>
<td>( F_7 )</td>
<td>-1.113</td>
</tr>
<tr>
<td>( F_8 )</td>
<td>-1.909</td>
</tr>
</tbody>
</table>

\( a \) Largest t-value. \( b \) Smallest t-value.

44. The sign pattern also reveals that there is no systematic indication of an effect on demand:

**Sign of coefficient**  | **Number of coefficients**

| “Significant” and positive | 1 |
| “Insignificant” and positive | 50 |
| “Insignificant” and negative | 46 |
| “Significant” and negative | 3 |

**Total** 100

45. It is perhaps easier to see the effect of demand by looking at the maximal impact of demand on price. We thus \( a \) calculate the elasticity of price with respect to capacity utilisation and \( b \) estimate the expected change of prices which would be observed in an average cycle. These
calculations are shown in Table VII and compared with the estimates obtained for manufacturing in the United States.¹

**Table VII**

*Calculated Elasticities and Cyclical Effects on Prices, U.K. and U.S. (a)*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Standard error.</td>
</tr>
<tr>
<td><em>Elasticities of price with respect to capacity utilisation:</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
<td>-0.032</td>
<td>0.0020</td>
</tr>
<tr>
<td>Preferred</td>
<td>0.000238</td>
<td>0.00036</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.0065</td>
<td>0.0032</td>
</tr>
<tr>
<td><em>Percentage</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effect of average cycle on price level: (c)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
<td>-0.32%</td>
<td>0.20</td>
</tr>
<tr>
<td>Preferred</td>
<td>0.0023%</td>
<td>0.0036</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.0055%</td>
<td>0.052</td>
</tr>
</tbody>
</table>

(a) For the U.K., these calculations refer to all demand variables. For the U.S. we consider only the Wharton index of capacity utilisation, constructed like $X_p$.

(b) These are estimates of $d log Y_i / d X_p$, where $p$ is actual price and $D_i$ is demand variable $i$.

(c) For the U.K., the average difference in values of peak to trough for $X_p$, our preferred demand variable, was 10%. The predicted percentage effect using this demand variable is then ten times the elasticity.

46. The conclusion from Table VII is that the effect of demand on prices over a normal cycle is uncertain but small. Our best guess is that going from trough to peak, other things the same, would on average raise prices by 0.002%. We would be surprised if the cyclical change in price were more than 0.1% in absolute value.

**Conclusion and Prospect**

47. The results reported above represent the first stage of a study about price behaviour in U.K. manufacturing industry. The results lead us to the following tentative assessment:

(i) We have constructed a series of predicted prices on the basis of independent cost data alone and without any reference to the actual behaviour of prices. The weights and lags on the different cost items were imposed solely on the basis of *a priori* considerations. When the

¹ For a survey and source of the American figures, see Nordhaus, op. cit. Comparisons of results for the U.S. and U.K. must be made with great care. Unit costs have not generally been normalised in U.S. studies. Moreover although the capacity utilisation series used for the U.S. is very similar to our $X_p$, both wholesale output and input prices indices for the U.S. are seriously defective in the weighting procedures. For a description, see *The Price Statistics of the Federal Government*, National Bureau of Economic Research: New York, 1961.
predicted and actual series are confronted, the behaviour of predicted prices traces out the actual pattern of price behaviour surprisingly well in view of the procedures used. The major discrepancy is the prolonged fall in the mark-up particularly during the period from 1961 to 1969.

(ii) Given the reasonable behaviour of the predicted price series, we feel that it forms a proper, if tentative, basis for testing the cyclical behaviour of actual prices. The method of comparison was to determine if there was any correlation between cyclical (or demand) variables and price after normal cost changes were accounted for. Having tried many different demand variables and alternative functional forms, we found that demand did not contribute in either a systematic or a significant way. If we take either the largest or the smallest estimated effect of demand, the effect on price over the average business cycle would be negligible.

(iii) We thus tentatively conclude that for non-food manufacturing industry the normal price hypothesis is correct. We further believe that while alternative and more refined methods will improve the degree of explanation we can achieve, it seems to us improbable that errors in the data, or incorrect assumptions or specifications, have combined in such a way as to eliminate a cyclical influence which was, in reality, present.

48. A number of further experiments will be carried out in the next stage of our inquiry. One important variant will be to treat the price of steel as exogenous—an input into our system—rather than as determined in the same way as other manufacturing prices. This seems appropriate because we know that the price of steel was controlled by public policy to a greater or lesser degree throughout much of the period, especially since 1966, and was frozen for considerable periods. We also know that over the whole period there was an absolute decline in steel profits, which made a large contribution to the decline in the overall profit ratio. It does not seem appropriate to include an industry in which price was strongly influenced by political considerations. Another variant will be to include food, drink and tobacco (both on the input and output side), and also to include export prices.

49. When completed the work described above will provide the starting point for a new and in many ways more important series of investigations. It will be by an examination of our predicted price series that we hope to test a number of further hypotheses. These include the following:

(a) The imposed lag structure should itself be tested, for example, by assuming that costs are passed on after less than the full historical lag. There are three major reasons why we have some reason to expect our lag profiles to need modification. First the calculated production periods assume by implication that profits are attributed in the valuation
of stocks. In practice this is usually not the case and our estimates of
the production period will be biased downwards as a result. Secondly
we are in some doubt, particularly in the case of basic materials, as to
precisely how the time at which the cost indicators are measured matches
entry of materials into the production and valuation process. For
instance, where prices are those quoted on commodity exchanges there
may be a lag between the time quotations change and the time the
commodity at its new price enters the production process. Third, some
pricing decisions may well be based on standard or replacement cost
practices.

(5) It should become possible to test certain hypotheses about tax
shifting in a new way. In particular we hope to discover something
about whether or not the employment subsidies (S.E.P. and R.E.P.)
were passed on; it should also be possible to discover something fairly
precise about the shifting of drink and tobacco taxes. It may even be
that we shall be able to carry out a new kind of investigation into
whether, and to what extent, company taxes and investment allowances
were shifted.

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WINNE GODLEY

Department of Applied Economics, Cambridge.

APPENDIX

THE DATA

1. The price of output was derived from the D.T.I.’s monthly index of wholesale
prices of home sales by manufacturing industry excluding food, drink and tobacco. The
price quotations which make up the index and their weights are chosen so as to
represent sales by the whole group of industries to outside purchasers, inter-
firm and inter-industry sales being netted out. In order to derive our quarterly
series it was necessary to link three base weighted indices, those based respectively

2. Indices of prices of materials and fuel purchased by manufacturing industry
are published by the D.T.I. on a basis exactly comparable, with respect to
coverage and weighting, with the output price index. Our quarterly series for
1953-69 were constructed by linking three indices based on the same years as the
output price index. After 1961 the price index of materials is not published
separately from fuel except on an annual basis; the quarterly series for materials
and fuel combined was split into its two components by interpolating these annual
series.

1 We should not overestimate this bias. Where stocks include an element of work bought in
from other manufacturing this will indeed include profits earned at an earlier stage of manufacturing
production.

2 The quarterly series for the prices of output and of materials and fuel were prepared by Mr.
John Rhodes.
3. For prices of services purchased by manufacturing industry we have been supplied with annual indicators of the cost of transport, distribution, construction and miscellaneous services from the data bank compiled at the Cambridge Department of Applied Economics for Professor Stone's input-output model of the British economy. These cost indices were added together using weights obtained from the input-output tables relating to 1963. From the resulting combined index a quarterly series was constructed by interpolation.

4. So far as the wages of manual operatives are concerned the various components were derived from the Historical Abstract of Labour Statistics (H.A.) published by the D.E.P., brought up to date with information in the D.E.P. Monthly Gazettes. Thus average hours were derived from Tables 43–45 of H.A. and standard hours from Tables 23 and 24. The index of standard hours was converted into numbers of hours using the benchmark for January 1956. Average weekly earnings were taken from H.A., Tables 41 and 42. Both actual hours and actual earnings are measured bimonthly. Throughout, the data relate to total manufacturing and do not—as strictly they should—exclude food, drink and tobacco. However, the number of workers in food, drink and tobacco is small and changes in their hours and earnings are so similar to those in the rest of manufacturing industry that it is doubtful whether their inclusion is a serious blemish.

5. Average salaries were inferred on an annual basis from the 1965 Blue Book (Table 17) and the 1970 Blue Book (Table 18) and a quarterly series derived by interpolation.

6. Total employment in manufacturing industry was derived from H.A. (Table 141) adjusted to include the self employed. These aggregate series were split into operatives on the one hand, and administrative, technical and clerical workers (A.T.C.s) on the other. This split was carried out by using the A.T.C. proportions published in the D.E.P. Historical Abstract (Table 144) which only gives one observation per annum for the period 1953 to 1962; from 1963 two observations per annum are given. Finally, both for operatives and A.T.C.s a quarterly index of male equivalent employment was constructed by weighting males and females in proportion to their average 1962–64 weekly earnings.

7. For employers' contributions (National Insurance and others) a quarterly series with the correct coverage was constructed from the annual series for manufacturing in the N.I. accounts and interpolated using the quarterly series in the N.I. accounts for total employment.

8. Finally, so far as indirect taxation is concerned, the main elements of these were hydrocarbon oil duties and local authority rates. We obtained a quarterly index, using some fairly arbitrary apportionment and interpolation, from the breakdown of taxes paid by these industries in the Census years, from the Blue Book estimates of the total yield of each tax in every year and, where obtainable (e.g., in the case of hydrocarbon oils), from the rates of tax themselves and the dates on which they were changed.

9. The capacity utilisation index (CU or $X_1$ in the text) was calculated from a regression of the logarithm of output on a time trend. The prediction from the regression was treated as normal output, $X_N$. The logarithm of the ratio of actual to normal output was then defined as capacity utilisation:

$$CU_t = \ln\left(\frac{X_t}{X_N}\right).$$
The Table of Identities

10. The coherence of the cost and price information may to some extent be tested in the set of calculations presented in Table A-1 below. This shows (in italics) for the years 1954, 1963 and 1968 estimates derived from the Censuses of Production of the gross output of manufacturing industry (free of duplication) and its components. The remaining figures not in italics will be described below.

11. Several aspects of the Table of Identities are remarkable. First, it should be noted that most of the series are independently gathered and there is no compensating item which even vaguely assures that the total value of production equals total income. Second, the residual in the Table of Identities is extremely small, at no time reaching 2% of total value of production. Moreover, the procedure estimates the value of output remarkably well for years in which we have Censuses of Production. The estimates of value of bought-in materials and to a lesser extent services agree reasonably well with the Census estimates in terminal years, implying that our assumption of constant unit inputs for these is substantially correct. These correspondences indicate that, taken as a whole, the data is remarkably coherent.  

12. A line-by-line description of data in Table A-1 is now given.

Line 1. This is essentially the C.S.O. index of manufacturing production excluding food, drink and tobacco, published in the Annual Abstract and the Monthly Digest of Statistics. Our object is to obtain an index of the value of gross output by multiplying the index of production by the index of prices. However, this procedure could produce inaccurate results because both published indices are base weighted. In order to avoid this difficulty, a new index of production was obtained by recalculating the index using 1968 weights. As it happens, this correction made little difference, raising the 1968 value by about 0.3 per cent.

Line 2 shows the output price index used in this study, on an annual basis. For a description of the compilation of this series, see D.T.I., Trade and Industry, Volume 2, No. 8, February 24, 1971, at page 407.

Line 3 is the product of Lines 1 and 2 scaled so that 1963 = 100.

Line 4 (excluding the first and last columns) is the implied value of gross output (£ million) obtained by multiplying line 3 by the 1963 Census gross value of output (£13,442).

Line 5 shows wages and salaries obtained from the 1965 and 1971 National Income and Expenditure Blue Book Tables (respectively) 17 and 18 plus employers' contributions. The latter series was obtained as the difference between the wage and salary bill and the total of income from employment in the 1954, 1967 and 1968 Censuses of Production, with interpolation for the intermediate years.

1 The authors are grateful to Mr. John Llewellyn for preparing this section and to Mr. Vivian Woodward for supplying us with his estimates of gross output and its components in 1954 converted so as to have the same coverage and definitions as those published for 1963 and 1968.

2 Several readers of an early draft questioned whether the results published in The Behavior of Industrial Prices, New York, N.B.E.R., 1970, by George Stigler and James Kindahl would invalidate our procedures. The residuals in Table A-1 appear, however, to be if anything pro-cyclical—the contrary of what would occur if transactions prices were shaded relative to list prices in recessions and vice versa.
<table>
<thead>
<tr>
<th>Table A-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Output and its Components</td>
</tr>
<tr>
<td>Manufacturing other than Food, Drink and Tobacco</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>1954</th>
<th>54</th>
<th>55</th>
<th>56</th>
<th>57</th>
<th>58</th>
<th>59</th>
<th>60</th>
<th>61</th>
<th>62</th>
<th>1953</th>
<th>64</th>
<th>65</th>
<th>66</th>
<th>67</th>
<th>68</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Index of production</td>
<td>77.3</td>
<td>83.2</td>
<td>82.4</td>
<td>84.4</td>
<td>82.9</td>
<td>88.1</td>
<td>95.8</td>
<td>95.7</td>
<td>95.9</td>
<td>100.0</td>
<td>100.9</td>
<td>113.4</td>
<td>115.1</td>
<td>114.9</td>
<td>122.4</td>
<td></td>
</tr>
<tr>
<td>2. Output Price Index</td>
<td>82.0</td>
<td>84.6</td>
<td>88.4</td>
<td>91.8</td>
<td>93.0</td>
<td>95.6</td>
<td>95.0</td>
<td>97.6</td>
<td>98.9</td>
<td>100.0</td>
<td>101.9</td>
<td>104.6</td>
<td>107.3</td>
<td>108.2</td>
<td>115.4</td>
<td></td>
</tr>
<tr>
<td>3. Value of Production Index</td>
<td>63.8</td>
<td>70.4</td>
<td>72.8</td>
<td>77.5</td>
<td>77.1</td>
<td>82.5</td>
<td>91.0</td>
<td>93.4</td>
<td>94.8</td>
<td>100.0</td>
<td>111.6</td>
<td>118.6</td>
<td>123.5</td>
<td>124.3</td>
<td>137.6</td>
<td></td>
</tr>
<tr>
<td>4. Value of Production—£m</td>
<td>8,545</td>
<td>8,576</td>
<td>9,463</td>
<td>9,708</td>
<td>10,418</td>
<td>10,364</td>
<td>11,090</td>
<td>12,232</td>
<td>12,555</td>
<td>12,745</td>
<td>13,445</td>
<td>14,001</td>
<td>15,942</td>
<td>16,601</td>
<td>16,706</td>
<td>18,406</td>
</tr>
<tr>
<td>5. Income from Employment—£m</td>
<td>5,355</td>
<td>6,355</td>
<td>3,702</td>
<td>4,006</td>
<td>4,247</td>
<td>4,392</td>
<td>4,600</td>
<td>5,016</td>
<td>5,360</td>
<td>5,507</td>
<td>5,672</td>
<td>6,206</td>
<td>6,786</td>
<td>7,230</td>
<td>7,314</td>
<td>7,895</td>
</tr>
<tr>
<td>6. Materials—Price index</td>
<td>95.7</td>
<td>95.7</td>
<td>95.7</td>
<td>95.7</td>
<td>95.7</td>
<td>95.7</td>
<td>95.7</td>
<td>95.7</td>
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<td>95.7</td>
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<td>95.7</td>
<td>95.7</td>
<td>95.7</td>
<td>95.7</td>
<td>95.7</td>
</tr>
<tr>
<td>7. Value, £m</td>
<td>2,187</td>
<td>2,140</td>
<td>2,412</td>
<td>2,496</td>
<td>2,605</td>
<td>2,343</td>
<td>2,503</td>
<td>2,751</td>
<td>2,746</td>
<td>2,714</td>
<td>2,872</td>
<td>3,268</td>
<td>3,475</td>
<td>3,866</td>
<td>3,570</td>
<td>4,228</td>
</tr>
<tr>
<td>8. Services—Price index</td>
<td>71.4</td>
<td>71.4</td>
<td>71.4</td>
<td>71.4</td>
<td>71.4</td>
<td>71.4</td>
<td>71.4</td>
<td>71.4</td>
<td>71.4</td>
<td>71.4</td>
<td>71.4</td>
<td>71.4</td>
<td>71.4</td>
<td>71.4</td>
<td>71.4</td>
<td>71.4</td>
</tr>
<tr>
<td>9. Value, £m</td>
<td>1,101</td>
<td>1,200</td>
<td>1,379</td>
<td>1,445</td>
<td>1,535</td>
<td>1,594</td>
<td>1,640</td>
<td>1,651</td>
<td>2,011</td>
<td>2,178</td>
<td>2,428</td>
<td>2,503</td>
<td>2,745</td>
<td>2,809</td>
<td>3,186</td>
<td>3,170</td>
</tr>
<tr>
<td>10. Intermediate Tax, £m</td>
<td>137</td>
<td>130</td>
<td>166</td>
<td>181</td>
<td>190</td>
<td>201</td>
<td>215</td>
<td>230</td>
<td>281</td>
<td>294</td>
<td>293</td>
<td>318</td>
<td>319</td>
<td>365</td>
<td>356</td>
<td>416</td>
</tr>
<tr>
<td>11. Sales by Final Buyers, £m</td>
<td>67</td>
<td>78</td>
<td>90</td>
<td>87</td>
<td>95</td>
<td>95</td>
<td>101</td>
<td>112</td>
<td>115</td>
<td>117</td>
<td>122</td>
<td>137</td>
<td>146</td>
<td>152</td>
<td>153</td>
<td>189</td>
</tr>
<tr>
<td>12. Total Costs, £m</td>
<td>6,847</td>
<td>6,392</td>
<td>7,749</td>
<td>8,205</td>
<td>8,681</td>
<td>8,555</td>
<td>9,060</td>
<td>9,943</td>
<td>10,433</td>
<td>10,653</td>
<td>11,138</td>
<td>12,357</td>
<td>13,319</td>
<td>14,679</td>
<td>14,127</td>
<td>15,751</td>
</tr>
<tr>
<td>13. Profit, source I*</td>
<td>1,698</td>
<td>1,698</td>
<td>1,813</td>
<td>1,762</td>
<td>1,771</td>
<td>1,942</td>
<td>2,043</td>
<td>2,305</td>
<td>2,153</td>
<td>2,000</td>
<td>2,304</td>
<td>2,567</td>
<td>2,657</td>
<td>2,440</td>
<td>2,734</td>
<td>2,734</td>
</tr>
<tr>
<td>14. Profit, source II*</td>
<td>1,698</td>
<td>1,698</td>
<td>1,755</td>
<td>1,716</td>
<td>1,942</td>
<td>1,806</td>
<td>2,022</td>
<td>2,262</td>
<td>2,096</td>
<td>2,074</td>
<td>2,304</td>
<td>2,573</td>
<td>2,636</td>
<td>2,502</td>
<td>2,661</td>
<td>2,734</td>
</tr>
<tr>
<td>15. Residual I, £m</td>
<td>0</td>
<td>-54</td>
<td>-99</td>
<td>-181</td>
<td>-184</td>
<td>-105</td>
<td>-99</td>
<td>8</td>
<td>27</td>
<td>26</td>
<td>36</td>
<td>0</td>
<td>71</td>
<td>-13</td>
<td>20</td>
<td>-80</td>
</tr>
<tr>
<td>16. Residual II, £m</td>
<td>0</td>
<td>-38</td>
<td>-41</td>
<td>-139</td>
<td>-139</td>
<td>-105</td>
<td>-97</td>
<td>8</td>
<td>27</td>
<td>28</td>
<td>36</td>
<td>0</td>
<td>71</td>
<td>-13</td>
<td>20</td>
<td>-80</td>
</tr>
</tbody>
</table>

* Alternative profit series I and II derived from Tables 17 and 32 of National Income and Expenditure Tables—see text.
Line 6 shows the index of prices of materials and fuel used in this study.
Line 7 is obtained by multiplying the price index by the index of the volume of production (row 1)—on the implicit assumption that unit material inputs were constant—and multiplying the resultant index by the 1963 Census of Production value of £m 2,872.
Line 8 gives the index of the price of transport, distribution and other services compiled by V. H. Woodward of the Cambridge Growth Project, Department of Applied Economics, Cambridge.
Line 9 shows the estimated value of bought-in services obtained by multiplying the price index by the index of the volume of production (row 1), and multiplying the resultant index by the 1963 Census of Production value of £m 2,178.
Line 10 estimates (net) intermediate taxes. Indices were prepared of the tax rates on motor spirit and derv, fuel oil, motor vehicle licences, Purchase Tax, and S.E.T., to which volume indices were applied to obtain estimates of tax paid. To this figure was added an estimate of local authority rates paid, while estimated receipts of the Selective and Regional Employment premiums, together with other subsidies, were subtracted. The final series of total net tax paid was scaled to agree with the 1963 Census of Production value of £m 293.
In Line 11 it was assumed that sales by final buyers moved in proportion with the value of production.
Line 12 shows total costs—the sum of rows 5, 7, 9, 10 and 11.
Line 13. This series shows gross profits of companies and trading surpluses of public corporations, Table 16(17) of the National Income and Expenditure Blue Book for 1965 (1971) plus income from self employment and other trading income from the same tables, less profits of the Food, Drink and Tobacco industries obtained from Table 30 (32). Stock appreciation, inferred from Tables 63 and 64 (67 and 66) of the National Income and Expenditure Blue Books is subtracted to make the profit series compatible with national income concepts.¹
Line 14. This series shows gross profits of manufacturing companies operating in the United Kingdom, Table 30 (32) of the 1965 (1971) National Income and Expenditure Blue Book, other than food, drink and tobacco. These profit figures are based on the industrial analysis of tax assessments made by the Inland Revenue, and do not completely correspond to the National Income definition of profit—see National Accounts Statistics, Sources and Methods, ed. Rita Maurice, H.M.S.O., 1968, page 216. After deducting stock appreciation (see notes to line 13) the series, together with the value of income from self-employment and other trading income taken from Table 17, was scaled to the 1963 Census of Production value of £m 2,304.² The movement of the two profit series is very close, except in 1967 and 1968. To date this discrepant movement in the two years has not been satisfactorily explained.
Lines 15 and 16 show differences between the calculated value of gross output (line 4) and the sum of all its observed or estimated components.

¹ The figures in line 13 of Table A-1 have been adjusted to make them agree with the input-output estimates in 1954 and 1968.
² The surplus earned by nationalised iron and steel was included in the total to line 14 of Table A-1.
Construction of the lag profiles

13. The following discussion\(^1\) describes in detail our derivation of the lag structure. The assumptions necessary for this derivation are given in paragraphs 28–33 of the text.

14. The calculation of the average production period for all our main industry groups and for total manufacturing is shown in Table A-2 on various assumptions about the value of \(\beta\), the share of material entering at the beginning of the period of production. Our estimates will only be correct under the condition that firms attribute profit in the valuation of stocks. As individual firms usually do not

<table>
<thead>
<tr>
<th>Table A-2</th>
<th>Production Period ((\theta)) by Industry*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 Chemicals.</td>
</tr>
<tr>
<td>1. Total sales ((£ m))</td>
<td>2,342</td>
</tr>
<tr>
<td>2. Total stocks and work in progress ((£ m))</td>
<td>492</td>
</tr>
<tr>
<td>3. Purchases of materials from outside manufacturing ((£ m))</td>
<td>647</td>
</tr>
<tr>
<td>4. Purchases of materials from manufacturing ((£ m))</td>
<td>214</td>
</tr>
<tr>
<td>5. Share of materials in sales ((- = \alpha))</td>
<td>0.3676</td>
</tr>
<tr>
<td>6. Production period ((\theta)) (measured in quarters)(\dagger)</td>
<td></td>
</tr>
<tr>
<td>(a) (\beta = \frac{3}{4})</td>
<td>1.350</td>
</tr>
<tr>
<td>(b) (\beta = \frac{1}{2})</td>
<td>1.229</td>
</tr>
<tr>
<td>(c) (\beta = 0)</td>
<td>1.081</td>
</tr>
</tbody>
</table>

Source: 1963 input–output tables.
* Figures all relate to the year 1963. Sales and purchases by each industry group (including the total) are free of duplication. For this reason the individual columns do not always add to the total.
\(\dagger\) \(\beta\) is the share of materials entering at the beginning of the period of production.

include their own profit we have probably introduced some downward bias into the estimates of the period of production, \(\theta\); this may not however be very large because stocks include materials bought in from other manufacturing firms which do include manufacturing profits.

15. If all manufacturing industry consisted of a single firm, with the cost structure and stock/output ratios shown in column 6 of Table A-2, it would be simple to work out the lag structure for materials entering at the beginning of the productive process (hereafter called "initial entry" inputs) and that for materials, fuel and other inputs which are added progressively throughout it (hereafter called "progressively added" inputs). Since the period of production \((\theta)\) is 2-9 quarters (assuming \(\beta\) to be 2/3), a step increase in the cost of initial entry inputs

\(^1\) Mr. Ken Goutts is responsible for the exposition of this section.
at a point of time will have its impact after exactly 2.9 quarters. By contrast a step increase of \(x\%)\ in progressive entry input costs will feed through by a steady \((x/2.9)\%)\ per quarter until \(\theta\) is completed.

\[ \text{Table A-3} \]

**Lag Structure by Industry Group**

(a) Materials entering at beginning of the process

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Chemicals</td>
<td>0</td>
<td>0.6500</td>
<td>0.3500</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2. Metals</td>
<td>0</td>
<td>0.3196</td>
<td>0.0804</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3. Engineering</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.9724</td>
<td>0.0276</td>
</tr>
<tr>
<td>4. Textiles</td>
<td>0</td>
<td>0</td>
<td>0.7064</td>
<td>0.2136</td>
<td>0</td>
</tr>
<tr>
<td>5. Other</td>
<td>0</td>
<td>0.7324</td>
<td>0.2676</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

(b) Inputs added progressively

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Chemicals</td>
<td>0.3704</td>
<td>0.5842</td>
<td>0.0454</td>
<td>0</td>
</tr>
<tr>
<td>2. Metals</td>
<td>0.2975</td>
<td>0.5647</td>
<td>0.1378</td>
<td>0</td>
</tr>
<tr>
<td>3. Engineering</td>
<td>0.1652</td>
<td>0.3303</td>
<td>0.3303</td>
<td>0.1741</td>
</tr>
<tr>
<td>4. Textiles</td>
<td>0.2259</td>
<td>0.4517</td>
<td>0.3121</td>
<td>0.0103</td>
</tr>
<tr>
<td>5. Other</td>
<td>0.3944</td>
<td>0.5775</td>
<td>0.0283</td>
<td>0</td>
</tr>
</tbody>
</table>

Note:

Time is measured in quarters. Figures show the proportional distribution of a cost increase (occurring in quarter 0) over succeeding quarters 1, 2, 3, etc. We interpolate the discrete data by assuming that changes occur uniformly or smoothly during the quarter. Thus, for part (a) of Table A-3, if the period of production is \(n \leq \theta < n + 1\), the proportion \((1 + n - \theta)\) will, for materials entering at the beginning, show up \(n\) quarters hence, and \((\theta - n)\) will show up \((n + 1)\) quarters hence.

16. Our purpose is to calculate how long it takes for a change in any particular cost component to feed through into the price charged to domestic final (or, strictly, domestic non-manufacturing) buyers. Table A-3 tells us how long it takes for each broad industry group to change its price in response to changes in the “initial entry” and “progressive” categories of costs. If all sales were to domestic final buyers, we would now only need to know the proportions of each category of cost item purchased by each industry (shown in Table A-4) to work out the lag profiles for each cost component.

\[ \text{Table A-4} \]

**Purchases by Industry Group**

<table>
<thead>
<tr>
<th></th>
<th>1 Chemicals</th>
<th>2 Metals</th>
<th>3 Engineering</th>
<th>4 Textiles</th>
<th>5 Other</th>
<th>6 Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of all purchases of initial entry materials from outside</td>
<td>0.2801</td>
<td>0.1563</td>
<td>0.1762</td>
<td>0.1944</td>
<td>0.1931</td>
<td>1.000</td>
</tr>
<tr>
<td>Proportion of all purchases of progressive inputs including labour</td>
<td>0.1256</td>
<td>0.1016</td>
<td>0.4344</td>
<td>0.1263</td>
<td>0.2121</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Source: 1963 input-output Tables.

17. An increase at a point of time in one of the two cost components shown in Table A-4 would turn up as an increase in prices subsequently through time as follows:
Quarter  0  1  ...  \((t - 1)\)
Increase in price  \(\sum_{i=1}^{n} x_i a_{i1}\)  \(\sum_{i=1}^{n} x_i a_{i2}\)  ...  \(\sum_{i=1}^{n} x_i a_{it}\)

where \(x_i\) is the \(i\)th column of the appropriate row of Table A-4 (depending on whether the input is progressive or initial entry) and \(a_{ik}\) is the element in the \(i\)th row and \(k\)th column of Table A-3. Consider a purchase of labour by chemicals. The coefficient \(x_2 = 0.1256\) represents the fraction of all labour bought by chemicals; while the coefficient \(a_{32} = 0.1400\) equals the fraction of output produced by that labour which exists from chemicals in quarter 2.

18. The position is even more complicated than this because a proportion of sales by each industry group goes either to exports or back into another part of manufacturing industry. The relevant flow table is shown in Table A-5.

<table>
<thead>
<tr>
<th>Proportion of own sales to:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chemicals</td>
<td>Metals</td>
<td>Engineering</td>
<td>Textiles</td>
<td>Other.</td>
</tr>
<tr>
<td>1. Home non-manufacturing</td>
<td>0.5124</td>
<td>0.1589</td>
<td>0.0444</td>
<td>0.7063</td>
<td>0.7196</td>
</tr>
<tr>
<td>2. Exports</td>
<td>0.2169</td>
<td>0.1346</td>
<td>0.2954</td>
<td>0.2222</td>
<td>0.0973</td>
</tr>
<tr>
<td>3. Engineering</td>
<td>0.0717</td>
<td>0.6491</td>
<td>0.0000</td>
<td>0.0242</td>
<td>0.1160</td>
</tr>
<tr>
<td>4. Other manufacturing</td>
<td>0.1990</td>
<td>0.0374</td>
<td>0.0602</td>
<td>0.0473</td>
<td>0.0659</td>
</tr>
<tr>
<td>Total</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Source: 1963 input-output tables.

19. In this more complex situation, changes in cost turn up at the end of the period of production in the prices charged to the various purchasers. This change is shown in Table A-6 as a matrix \(B\), where the typical element, \(b_{ij}\), represents the increase in price for buyer \(j\) in quarter \((t - 1)\). It is calculated as:

\[
b_{ij} = \sum_{t=1}^{5} x_i y_{jt} a_{it}
\]

where \(x_i\) and \(a_{it}\) were defined above and \(y_{jt}\) = the fraction of sales of industry \(j\) to buyer \(i\) shown in Table A-5.

<table>
<thead>
<tr>
<th>Purchaser</th>
<th>Quarter</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>...</th>
<th>((t - 1))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Home final buyer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(\sum_{t=1}^{5} x_i y_{t1} a_{i1})</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Exports</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(\sum_{t=1}^{5} x_i y_{t2} a_{i1})</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Engineering</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(\sum_{t=1}^{5} x_i y_{t3} a_{i1})</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Other manufacturing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(\sum_{t=1}^{5} x_i y_{t4} a_{i1})</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
20. The third and fourth rows of Table A-6 show how changes in the cost of inputs purchased from outside manufacturing feed back into the system again as changes in the cost of goods purchased by one part of manufacturing from another. The first row represents the distributed lag on inputs which should show up in our price index as a result of the "first round" of production. The second row is irrelevant for our study, while rows 3 and 4 show how materials recycle through manufacturing. The next stage is to ascertain how these "first round" changes in the prices of intermediate goods work through the system. A proportion will emerge as changes in prices charged to final buyers and the rest will feed back yet again as higher prices for intermediate goods purchased by manufacturing industry. This process goes on until all purchases by manufacturing emerge from the system.

21. When the calculations for this article were undertaken a routine had not been written to calculate the lags iteratively, so the process was approximated by hand. The "first round" was calculated precisely as shown in Table A-6 above, and it was found that 75% of all materials and over 80% of other outputs exit from the system at that stage. In calculating the second round some corners were cut; for instance all intermediate materials were assumed to enter at the beginning of the productive process. After the second round only about 3% re-entered the system, and this was allocated by force majeure.