An Input-Output Analysis of the De-Industrialisation of the U.K. Economy, 1963-1973 *

I. Introduction

This paper has two aims: (i) to estimate output and price elasticities of sectors as well as the whole economy, and (ii) to find out the reasons why the phenomenon of de-industrialisation, i.e. the decline in the share of output of the manufacturing sector in the whole national output, has been observed in advanced countries such as the U.K. in recent decades. We use, for this purpose, input-output tables which are combined with sectoral production functions (of the Cobb-Douglas type) to represent the supply side. Personal consumption of goods and services is regarded as endogenous.

To estimate output and price elasticities, we confine ourselves to the case of sectoral exogenous demands all changing proportionately. If the elasticities of outputs with respect to a proportional change in the exogenous demands are found to be all equal to 1, so that the price elasticities are all 0, the economy may be said to be a perfect fixprice economy, while when they all take on 0 and the price elasticities are all 1, it is a perfect flexprice economy, or, according to Keynes, an economy which is under a "true inflation". Comparing our estimates for the U.K., 1963-1973, with those for Japan, 1960-1975, and Italy, 1965-1975, calculated in the same way, we find that price elasticities are generally higher in Italy and Japan than in Britain; so that a flex-

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TABLE 1

THE U.K. INDUSTRIAL DISTRIBUTION OF THE NATIONAL INCOME AT FACTOR COST (%)

Industry \ Year	1963	1968	1970	1971	1972	1973
Agriculture	3.56	3.07	2.96	2.84	2.89	2.96
Manufacturing	33.41	32.81	32.57	31.22	30.40	30.05
Non-manufacturing	20.83	20.76	19.82	19.64	20.45	21.26
Services	26.44	25.92	25.36	26.67	26.14	25.81
Public Administration	15.76	17.45	19.30	19.63	20.08	19.92

price neoclassical model would better fit Japan and Italy than a fixprice Keynesian one, while the opposite would be true for the British economy.

As for the de-industrialisation, we discuss it from the viewpoint of the distribution of value added rather than the distribution of the working population among sectors. By using input-output tables we obtain the total income of sector i at factor cost as:

(the value added ratio) × (output of industry i) =

= (the value added ratio) × (the inter-industrial output matrix multipliers) × (the exogenous demands),

which is equal to:

(the sectoral income multipliers) × (the exogenous demands).

Therefore the fluctuations of the sectoral income can be reduced to the fluctuations in the two factors: multipliers and multiplicants (the exogenous demands). Although, as will be seen, the aggregate multiplier has declined in the period with which we are concerned, the sectoral multipliers have changed in such a way that agriculture and the

manufacturing industry will decline and the public administration sector will increase. There are a number of factors which may induce such changes: (i) tax effects, (ii) consumption effects, (iii) exogenous (or final) demand effects, (iv) import substitution effects, and (v) technology effects. By the use of the available input-output tables for the U.K. these effects are quantitatively identified and their significance compared with each other. Among the five items above, although it is found by simulations that (i) and (iv) have fairly large effects on the values of the sectoral and aggregate multipliers, their effects upon the distribution of national income among industries are seen to be generally small; it is found that the movement of sectoral shares of income through time is explained to a large extent by the final demand effects.

Section II describes the model. Section III presents estimates of the various multipliers, Section IV analyses those which we call the "fixprice" multipliers into the five effects mentioned above and Section V analyses the process of de-industrialisation in the U.K., 1963-1973.

II. The model

The model used is a conventional Leontief model with endogenous consumption. Coefficient α_{ij} represents a value input coefficient,

$$\alpha_{ij} = \frac{p_i x_{ij}}{p_j x_j}, \quad i, j = 1, ..., n, \tag{1}$$

that is, the value of output i which is necessary to produce one unit value of output j, where x_{ij} is the total physical input of commodity i for production of the total physical output of j, x_j, and p_i, p_j are prices of respective commodities i and j. Obviously, the physical input coefficient is defined as $\xi_{ij} = x_{ij}/x_j$. Of course, in the actual input-output tables industries produce a number of heterogeneous outputs, but throughout this paper we proceed with our analysis as if each industry produced a single output. Following Klein we make an assumption which is consistent with Leontief's empirical findings and theoretical model; that is, constant are value input coefficients (rather than physical ones) as well as the import coefficients β_j and share of wages γ_j of each industry j. We also assume that competitive pricing prevails.[1]

It has been shown that these two assumptions together imply that the industrial production functions are of the Cobb-Douglas form:

$$x_j = G_j \, x_{1j}^{\alpha_{1j}} \dots x_{nj}^{\alpha_{nj}} \, l_j^{\gamma_j} \, m_j^{\beta_j} , \qquad (2)$$

where G_j is the productivity coefficient, l_j the labour input, and m_j the input of imported goods. With (2) we obtain (1) as the marginal productivity equation (or competitive pricing rule) for x_{ij}. We also have similar equations for l_j and m_j. Thus

$$\beta_j = \frac{q_j m_j}{p_j x_j}, \qquad \gamma_j = \frac{w_j l_j}{p_j x_j}, \qquad (3)$$

where q_j represents the price of the composite commodity 'imports of industry j' and w_j the wage rate in industry j.[2]

As for consumption expenditure decisions we assume that they may be represented by a Linear Expenditure System (Stone (1954)). Let b be the marginal propensity to consume, ε_i the proportion of the total consumption expenditure which is spent on the output of industry i, π_j the share of profit in the output of j, η the proportion of profits distributed to individuals, and t_w and t_π the tax rates on wages and profits respectively. Then the increase in the consumption demand for good i which will arise from an increase in the output of industry j will be proportional to

$$c_{ij} = \varepsilon_i \, b \, \{(1 - t_w)\, \gamma_j + \eta \, (1 - t_\pi)\, \pi_j\}. \qquad (4)$$

In the following we assume γ_j, π_j, b and ε_i to be constant and write the augmented input-output coefficients as

$$a_{ij} = \alpha_{ij} + c_{ij} \qquad i, j = 1, \dots, n. \qquad (5)$$

Now the basic equations of input-output analysis are put in the form:

$$p_i x_i = \Sigma_j \, p_i x_{ij} + p_i C_i + p_i D_i, \qquad i = 1, \dots, n. \qquad (6)$$

or

$$X_i = \Sigma_j \, (\alpha_{ij} + c_{ij}) \, X_j + p_i D_i, \qquad i = 1, \dots, n. \qquad (7)$$

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1 We can extend our analysis to a more realistic case of allowing for joint production and market imperfections. See KLEIN (1952).

2 G_j depends on the capital equipment installed in industry j. For each input-output table it is assumed to be constant but it changes from one table to another exogenously; similarly for the other coefficients of the production function (2).

where C_i represents the endogenous part of the consumption demand for output i, and D_i the exogenous demand for the same output. Of course,

$$X_i = p_i x_i, \qquad i = 1, \dots, n. \qquad (8)$$

In view of (1) and (3) the 'indirect' production function can be derived from the 'direct' production function (2) as:[3]

$$x_i^{\alpha_i} = H_i \left(\frac{p_i}{p_1}\right)^{\alpha_{1i}} \dots \left(\frac{p_i}{p_n}\right)^{\alpha_{ni}} \left(\frac{p_i}{q}\right)^{\beta_i} \left(\frac{p_i}{w_i}\right)^{\gamma_i}, \qquad (9)$$

where $\alpha_i = 1 - \Sigma_j \alpha_{ji} - \beta_i - \gamma_i$ and H_i is an appropriate constant. We are now provided with two sets of n equations (7) and (9) representing the demand side and the supply side, respectively. They are connected with each other by n definitional equations (8). The variables contained in the whole three sets of n equations are $X_1, \dots, X_n, x_1, \dots, x_n, p_1, \dots, p_n, q_1, \dots, q_n, w_1, \dots, w_n, D_1, \dots, D_n$, so that by regarding the prices of the imported goods q_i's, wage rates w_i's and exogenous demands D_i's as all given, the equations (7) – (9) are altogether able to determine the values of outputs X_i's and the prices p_i's.

Three kinds of multipliers, total, real and fixprice, can be derived in the following way. Since total income generated in industry j, y_j, is equal to the value of gross output minus the value of inputs other than labour, including outlay taxes paid by industry j, and is distributed among workers and capitalists, we have

$$y_j = [1 - (1 + t_j)\,(\Sigma_i \alpha_{ij} + \beta_j)]\, p_j x_j = v_j p_j x_j, \qquad (10)$$

where t_j is the average outlay tax for industry j and v_j stands for the value-added ratio, $\gamma_j + \pi_j$. From this we obtain the effect of dD_k upon y_j as

$$\frac{dy_j}{dD_k} = v_j \left[\frac{\partial p_j}{\partial D_k} x_j + p_j \frac{\partial x_j}{\partial D_k}\right], \quad j = 1, \dots, n. \qquad (11)$$

In this expression we can obtain derivatives $\partial p_j / \partial D_k$ from (7) – (9),[4] and, therefore, derivatives $\partial x_j / \partial D_k$ from (9). On the right-hand side of (11) the first term of the part in square brackets gives the

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3 For the sake of simplicity the derivation has been made here at the industry level. It can, however, equally be made at the firm level. See MORISHIMA-MURATA (1972) pp. 257-59.

4 Regarding q_i's and w_i's as given, (9) gives x_i as a function of commodity prices p_j's. Substituting the x_i's thus obtained into (8), we have the values of output X_i's as functions of prices. The input-output (or demand-supply) equations (7) can be regarded as the price-determination equations, and from them we obtain $\partial p_j/\partial D_k$, j, k = 1, ..., n. See MORISHIMA-MURATA (1972) pp. 259-61.

nominal increase in $p_j x_j$ due to $\partial p_j / \partial D_k$ with x_j being unchanged and the second term the real increase in it due to $\partial x_j / \partial D_k$ with p_j unchanged. The total effect on y_j which includes the nominal increase gives the total multiplier, while the real multiplier is obtained by eliminating the nominal effect from the total one. Thus we may write:

$$\left(\frac{\partial y_j}{\partial D_k}\right)_T = v_j \left[\frac{\partial p_j}{\partial D_k} x_j + p_j \frac{\partial x_j}{\partial D_k}\right], \quad j = 1, \ldots, n. \qquad (12)$$

and

$$\left(\frac{\partial y_j}{\partial D_k}\right)_R = v_j p_j \frac{\partial x_j}{\partial D_k}, \qquad j = 1, \ldots, n. \qquad (13)$$

which represent the total and the real sectoral-income multipliers, respectively.

Let us now imagine a proportional change in the final demands, i.e.

$$dD_1 : dD_2 : \ldots : dD_n = D_1 : D_2 : \ldots : D_n .$$

Then

$$dD_k / dD = D_k / (\Sigma p_i D_i),$$

where $dD = \Sigma p_i \, dD_i$. We then have

$$\left(\frac{dy_j}{dD}\right)_T = \Sigma_k \left(\frac{\partial y_j}{\partial D_k}\right)_T \frac{D_k}{\Sigma p_i D_i}, \qquad j = 1, \ldots, n,$$

$$\left(\frac{dy_j}{dD}\right)_R = \Sigma_k \left(\frac{\partial y_j}{\partial D_k}\right)_R \frac{D_k}{\Sigma p_i D_i}, \qquad j = 1, \ldots, n,$$

These give the total and the real multiplier effects of a proportional change in the final demands.[5]

Being provided with these we can easily calculate the elasticities of output and price, e_{oj} and e_{pj}, respectively, in response to a change in effective demand measured in terms of money, y_j. When final demands increase proportionately, the effective demand for industry j changes by

$$dy_j = \left(\frac{dy_j}{dD}\right)_T dD \qquad (14)$$

[5] It should be noted that in our definition of the total income multipliers the inflationary effects of price changes are taken into account in calculating dy_j, while they are ignored in calculating the increments of the total value of the final demand, so that $dD = \Sigma p_i \, dD_i$; otherwise we should have $dD = \Sigma D_i \, dp_i + \Sigma p_i \, dD_i$ for dD. Then, with this new definition of dD, the estimates of the total

in money terms, while the real output by $dx_j = \left(\frac{dx_j}{dD}\right) dD$, where $\frac{dx_j}{dD} = \Sigma_k \left(\frac{dx_j}{dD_k}\right) \frac{D_k}{\Sigma p_i D_i}$. We then have from (13) and (10)

$$dx_j = \left(\frac{dx_j}{dD}\right) dD = \left(\frac{dy_j}{dD}\right)_R dD/(v_j p_j) = \frac{x_j}{y_j} \left(\frac{dy_j}{dD}\right)_R dD.$$

Therefore, in bearing (14) in mind, we find that the ratio of the real multiplier to the corresponding total multiplier gives the elasticity of output:

$$e_{oj} = \frac{y_j}{x_j} \frac{dx_j}{dy_j} = \frac{\left(\frac{dy_j}{dD}\right)_R}{\left(\frac{dy_j}{dD}\right)_T}.$$

Also, it can be seen that the ratio of the difference between the total and real multipliers to the total multiplier gives the elasticity of price:

$$e_{pj} = \frac{y_j}{p_j} \frac{dp_j}{dy_j} = \frac{\left(\frac{dy_j}{dD}\right)_T - \left(\frac{dy_j}{dD}\right)_R}{\left(\frac{dy_j}{dD}\right)_T}$$

Of course, $e_{oj} + e_{pj} = 1$ for $j = 1, \ldots, n$, because v_j is constant in (10).

Let us next derive the fixprice multipliers. Let A be the matrix of augmented input coefficients $(\alpha_{ij} + c_{ij})$; then equations (7) can be written in matrix form as

$$x = \hat{p}^{-1} A \hat{p} x + \underset{\sim}{D}, \qquad (7')$$

where x and $\underset{\sim}{D}$ are column vectors of dimension $(n \times 1)$ with components x_i and D_i, respectively, and $\hat{p}$ a diagonal matrix of dimension $(n \times n)$ with diagonal elements p_i. Differentiating (7') with respect to D_k, we have

$$\left(\frac{dx}{dD_k}\right)_F = \hat{p}^{-1} A \hat{p} \left(\frac{dx}{dD_k}\right)_F + \Delta_k \qquad (15)$$

on the assumption that all prices remain unchanged. Here Δ_k is a column vector of dimension $(n \times 1)$ having 1 as the k-th component and zeros elsewhere, and subscript F attached to dx/dD_k represents that $\hat{p}$ is kept constant in differentiation. With $(dx/dD_k)_F$ thus obtained, the fixprice sectoral-income multipliers are given as:

$$\left(\frac{dy_j}{dD}\right)_F = v_j p_j \left(\Sigma_k \left(\frac{dx_j}{dD_k}\right)_F \frac{D_k}{\Sigma p_i D_i}\right), \qquad (16)$$

when final demands are increased proportionately.

These 'fixprice' multipliers may be compared with the 'real' multipliers. Removing the assumption that prices are fixed, let us differentiate (7') with respect to D_k. Then,

$$\frac{dx}{dD_k} = \hat{p}^{-1}A\hat{p}\,\frac{dx}{dD_k} + \hat{p}^{-1}\left[A\frac{d\hat{p}}{dD_k}x - \hat{p}^{-1}\frac{d\hat{p}}{dD_k}A\hat{p}x\right] + \Delta_k \quad (17)$$

Solving, we obtain dx/dD_k, $k = 1, ..., n$, which can be shown to equal those dx_j/dD_k which are used in the formula (13) for calculating the real multipliers. Considering (15) we can see that the solutions to (17) may be written as

$$\frac{dx}{dD_k} = \left(\frac{dx}{dD_k}\right)_F + (I - \hat{p}^{-1}A\hat{p})^{-1}\hat{p}^{-1}\left(A\frac{d\hat{p}}{dD_k}x - \hat{p}^{-1}\frac{d\hat{p}}{dD_k}A\hat{p}x\right), \quad (18)$$

on the right-hand side of which the first term represents the effects on sectoral physical outputs which an increase in D_k would give rise to if prices could be held constant in spite of the increase, i.e., the fixprice sectoral-physical-output multipliers. On the other hand, the second term on the right-hand side gives the indirect effect of an increase in D_k upon sectoral outputs through the channel of price changes. These effects may further be split into two parts as is seen in (18). The matrix $\hat{p}^{-1}A\,\frac{d\hat{p}}{dD_k}$ gives the effects through the increases in output prices on the augmented physical input coefficients $\hat{p}^{-1}A\,\hat{p}$, while the matrix $\hat{p}^{-2}\frac{d\hat{p}}{dD_k}A\hat{p}$ the effects through the increases in input prices. Any (i, j) element of the difference between the two matrices tells us, if positive, that the output price p_j will rise more than the input price p_i. Hence, industry j will use a greater quantity of commodity i per unit production of commodity j, so that the price effects on the sectoral-output multipliers are positive; that is the flexprice sectoral-physical output multipliers (the complete expression of (18)) is larger than the corresponding fixprice output multipliers (the first term of (18)). Conversely, if it is negative, the input price p_i will rise more than the output price p_j; and the flexprice multipliers will be smaller than the corresponding fixprice multipliers.

If there were no errors in our estimation of the aggregate consumption function, then it is seen that the fixprice sectoral-income multipliers $\left(\frac{dy_j}{dD}\right)_F$ would be proportional to the sectoral incomes y_j, $j = 1, ..., n$. Let the column vector of sectoral incomes y_j's be denoted

by y which is $y = \hat{v}\hat{p}x$, where $\hat{v}$ is a diagonal matrix with value-added ratios, $v_j = \gamma_j + \pi_j$, on the diagonal. Considering (7) (which assumes that the aggregate consumption function is estimated accurately) and (8), we have

$$y = \hat{v}(I - A)^{-1}\hat{p}\underset{\sim}{D}.$$

We know, however, from (15) and (16) that

$$\left(\frac{dy}{dD}\right)_F = \hat{v}(I - A)^{-1}\hat{p}\underset{\sim}{D}/(\Sigma p_i D_i).$$

(Note that we assume that D_i's change proportionately.) Hence,

$$\frac{y_j}{Y} = \frac{\left(\frac{dy_j}{dD}\right)_F}{\left(\frac{dY}{dD}\right)_F}, \qquad j = 1, ..., n, \qquad (19)$$

where Y stands for the national income, i.e., Σy_j. Thus, by calculating the ratios of the fixprice sectoral-income multipliers to the fixprice national-income multiplier for various years, we can trace out how the distribution of the national income among industries has changed in these years.

III. Estimates of multipliers and output and price elasticities

Input-output tables for the United Kingdom, Japan and Italy are the main source from which the coefficients of our model are estimated, along the lines presented in section II above.[6]

1. *Fixprice multipliers*

Results are presented in Table 2, at a five-sector aggregation level for (I) 'agriculture', (II) 'manufacturing' (III) 'non-manufacturing industries', (IV) 'services', and (V) 'public administration'. Two features of

[6] For the estimation of t_w, t_π, η and the marginal propensity to consume, b, it was necessary to make use of a variety of sources (details of the estimation procedures are available on request). It is worthwile mentioning that the estimates for b were: .68 for the U.K., .55 for Japan, and .48 for Italy.

the aggregate national income multiplier are rather striking. First, its low level throughout the decade, with a maximum of 1.316 in 1963, is consistent with macro-econometric observations, say, on the basis of the Klein-Goldberger model by Goldberger (1959). Secondly, its steady fall between 1963 and 1970, followed by an increase in 1971 and 1972, and by another fall in 1973 to its 1970 level of 1.188. These values are compared with a similar estimate, 1.333, of the income multiplier for the U.K., 1954 by Morishima and Nosse.[7]

TABLE 2

FIXPRICE INCOME MULTIPLIERS FOR THE U.K.*

Industry \ Year	1963	1968	1970	1971	1972	1973
Agriculture	.046 (3.46)	.037 (2.98)	.034 (2.87)	.033 (2.77)	.035 (2.81)	.035 (2.92)
Manufacturing	.443 (33.67)	.408 (33.08)	.390 (32.81)	.379 (31.40)	.378 (30.62)	.358 (30.16)
Non-Manufacturing	.275 (20.91)	.257 (20.88)	.236 (19.89)	.238 (19.70)	.253 (20.54)	.253 (21.32)
Services	.342 (26.00)	.314 (25.47)	.297 (25.01)	.318 (26.38)	.318 (25.78)	.304 (25.62)
Public Administration	.210 (15.95)	.217 (17.61)	.231 (19.41)	.238 (19.75)	.250 (20.24)	.238 (19.99)
Total	1.316 (100.0)	1.232 (100.0)	1.188 (100.0)	1.206 (100.0)	1.233 (100.0)	1.188 (100.0)

* Figures in brackets give the percentages of sectoral multipliers to the corresponding national income multipliers.

Turning now to consider the dynamics of sectoral multipliers over the period, we can see how all four private sector multipliers were lower in 1973 than in 1963, and only that for public administration was higher. Two features of the results are particularly interesting: firstly, that

7 See MORISHIMA-NOSSE (1972), p. 139.

manufacturing is the only sector in which the decrease has been monotonic. Thus it would seem that the factors which in some years positively affected the multipliers in other sectors, did not have a relevant influence on manufacturing. Secondly the multiplier for services shows a considerable decrease over the period, and this does not seem to agree with conventional views simply interpreting the decline of manufacturing as stemming from a substitution of services for goods.

If there were no errors in our estimation of the aggregate consumption function, then, as formula (19) above shows, the ratio between the sectoral and national fixprice multipliers would be identical to the ratio between the sectoral and national value added. Thus, the comparison between the percentages given in the parentheses in Table 2 and the industrial shares of national income given in Table 1 enables us to obtain some idea of the significance of our error in estimating the aggregate consumption function. This is found to be of negligible size reaching a maximum, for manufacturing, of only 0.8% of the actual share of the sector.

2. *Real and total multipliers*

Let fixprice, real and total multipliers concerning sector i be denoted by μ_i, μ_i^* and μ_i^+, respectively. They of course satisfy the identities:

$$\mu_i^* = \mu_i + (\mu_i^* - \mu_i),$$

$$\mu_i^+ = \mu_i^* + (\mu_i^+ - \mu_i^*) = \mu_i + (\mu_i^* - \mu_i) + (\mu_i^+ - \mu_i^*)$$

In these, the difference between real and fixprice multipliers $\mu_i^* - \mu_i$, represents the price effect on the real income, while the difference between total and real multipliers, $\mu_i^+ - \mu_i^*$, represents the purely inflationary price effect on the nominal income. They are referred to as the real price effect and the inflationary price effect, respectively. Tables 3 and 4 show our estimates of real and total multipliers at the five-sector aggregation level, from which the real and nominal price effects can at once be derived. Of course the total price effect is obtained by adding up the two price effects.

Both real and total multipliers are seen to follow quite closely the general pattern of the fixprice multipliers, and all the remarks made on the last can be extended to the first two.

TABLE 3

REAL INCOME MULTIPLIERS FOR THE U.K.

Industry \ Year	1963	1968	1970	1971	1972	1973
Agriculture	.051	.039	.036	.037	.037	.036
Manufacturing	.478	.446	.430	.425	.427	.400
Non-Manufacturing	.269	.251	.236	.241	.262	.261
Services	.254	.245	.227	.217	.235	.232
Public Administration	.208	.214	.226	.236	.247	.231
Total	1.260	1.197	1.156	1.156	1.207	1.160

TABLE 4

TOTAL INCOME MULTIPLIERS FOR THE U.K.

Industry \ Year	1963	1968	1970	1971	1972	1973
Agriculture	.068	.056	.052	.051	.054	.052
Manufacturing	.656	.599	.560	.552	.552	.507
Non-Manufacturing	.440	.418	.378	.388	.417	.405
Services	.582	.537	.508	.567	.561	.510
Public Administration	.336	.352	.375	.389	.409	.389
Total	2.082	1.968	1.873	1.947	1.992	1.863

Price effects on real income are generally small, but of different signs for the different sectors; they are positive in all years for agriculture and manufacturing and in the last three years for non-manufacturing. On the other hand, they are negative in all years for services, public administration and at the aggregate level. As we have seen, a negative price effect for a sector will be observed when, as a consequence of the increase in final demand, the price of its output rises less than the price of the inputs it buys, while the converse is true for a positive price effect. Thus, we may say that price effects on real income are beneficial to agriculture and manufacturing, but not to services nor to national income.

Purely inflationary effects have accounted for a considerable portion of the total aggregate multiplier, being almost constant around 38%-39% of the latter throughout the period. Thus it would seem that final demand expansion policies have been consistently likely to give rise to considerable inflationary pressure in the sample years. At the sectoral level, the share of inflationary effects in the multiplier has undergone some interesting changes. It has steadily decreased in each year in manufacturing from 27% in 1963 to 21% in 1973, while it has steadily increased in public administration from 38% to 41% over the period (except 1971).

3. *Output and price elasticities*

In view of the formulas for the output and the price elasticities above we may write:

$$e_{oj} = \frac{\mu_j^*}{\mu_j^+}, \quad \text{and} \quad e_{pj} = 1 - e_{oj} = \frac{\mu_j^+ - \mu_j^*}{\mu_j^+}.$$

Since estimates of the real and the total multipliers are now provided, it is easy to calculate the elasticities. The results at the five-sector level are presented in Table 5 for price elasticities (output elasticities can be easily obtained as the complement to one of the price elasticities). These show that in the U.K. economy the agriculture and manufacturing sectors are fixprice-type sectors with low price elasticities, while the service sectors are of flexprice type with high price elasticities.

TABLE 5

PRICE ELASTICITIES FOR THE U.K.

Industry \ Year	1963	1968	1970	1971	1972	1973
Agriculture	.258	.299	.299	.274	.310	.308
Manufacturing	.271	.255	.233	.230	.226	.210
Non-Manufacturing	.389	.398	.376	.378	.372	.355
Services	.563	.543	.553	.617	.581	.545
Public Administration	.380	.391	.396	.394	.397	.406
Total	.395	.390	.383	.406	.394	.377

These results are confirmed by the detailed results at the 35-industry level. The average price elasticities over the six sample years take on a very low value (i.e. below 0.15) for such industries as coke ovens, instrument engineering, shipbuilding, aerospace equipment, other vehicles, leather, clothing and footwear, timber and furniture; a considerably low value (i.e. between 0.15 and 0.25) for agriculture, forestry and fishing, coal mining, other mining and quarry, food, drink and tobacco, mineral oil refining, non-ferrous metals, motor vehicles, textiles, bricks, other manufacturing, gas, communications; and a fairly low value (i.e. between 0.25 and 0.35) for iron and steel, mechanical engineering, electrical engineering, other metal goods, and paper and printing. The national average of the price elasticities over the six years is 0.39; the elasticities for the two service industries are clearly above the average, the distributive trades taking on 0.44 and miscellaneous services 0.64. The remaining industries (chemicals, construction, electricity, water, transport) have elasticities between 0.35 and 0.44.

In comparison with the results for Japan and Italy, presented in tables 6 and 7, it is observed that the Japanese and the Italian economy are generally more price elastic than the British, so that we may categorically say that the former two are of a 'flexprice' type, while the latter is more or less on the 'fixprice' side.

TABLE 6

PRICE ELASTICITIES FOR JAPAN

Industry \ Year	1960	1965	1970	1975
Agriculture	.546	.585	.475	.485
Manufacturing	.357	.344	.374	.268
Non-Manufacturing	.528	.551	.572	.504
Services	.931	.938	.981	.895
Public Administration	.433	.241	.211	.169
Total	.629	.657	.691	634

TABLE 7

PRICE ELASTICITIES FOR ITALY

Industry \ Year	1965	1970	1971	1972	1973	1974	1975
Agriculture	1.093	.929	.916	.866	.917	.833	.831
Manufacturing	.362	.347	.321	.326	.346	.343	.309
Non-Manufacturing	.607	.562	.564	.504	.495	.470	.465
Services	.680	.680	.680	.689	.675	.664	.698
Public Administration	.421	.340	.353	.351	.320	.246	.228
Total	.621	.573	.558	.552	.552	.527	.528

We may see, in particular, that:

— for agriculture price elasticities are extremely high in Italy, lower in Japan and lowest in Britain, so that, owing to diminishing returns to scale, an increase in demand has substantial inflationary effects in the first two countries;

— manufacturing is a 'fixprice' sector in all three countries; its price elasticities are considerably lower than those of the other sectors in each country in all years;

— for non-manufacturing price elasticities are somewhat higher in Italy than in Japan;

— the service industries show an extremely high price elasticity for Japan, lower for Italy and lowest for Britain: we may therefore observe that, of the two 'flexprice' economies, the Japanese one tends to develop demand-pulled inflationary pressures mainly in the service sector, while the Italian one in the agricultural sector;

— public administration shows lower than average price effects in each country, but this fact should be interpreted with care as this sector includes in Britain and Japan 'ownership of dwellings', so that its price elasticities result from the aggregation of a strongly 'fixprice' sector (public administration), with a strongly 'flexprice' sector (ownership of dwellings).

IV. An analysis of the fixprice multipliers by simulation experiments

It is clear from the exposition of our model in section II above that the values of income multipliers depend on:

(i) the technological coefficients α_{ij}, β_j, γ_j;

(ii) the portion of business profits distributed to individuals, η;

(iii) the direct and indirect tax rates, t_w, t_π, t_j;[8]

(iv) the marginal propensity to consume b;

(v) the coefficients of allocation of consumption expenditure among goods ε_j;

(vi) the structure of final demand, represented by ratios $\dfrac{p_k D_k}{\Sigma p_i D_i}$, $k = 1, \ldots, n$.

In this section we are concerned with the quantitative assessment of the influences on income multipliers of the factors (i), (iii), (v), (vi). We shall not be concerned here with the relevance of η, since this parameter showed very little variability throughout the period. Nor shall we discuss changes in the marginal propensity to consume, which we estimated as being constant over the period 1959-1977 by using a mixed time series-cross section method.

To assess the influences of the various factors on the fixprice multipliers, a number of simulations have been performed. We have computed the values of the multiplier for an hypothetical economic system having (say) the 1963 technology, demand and consumption structures but, as for the direct and indirect tax rates, having those which were actually observed in 1968.

The difference between this hypothetical multiplier (μ_T) and the actual multiplier for 1963 (μ_{63}), then, gives us a measure of the importance of direct and indirect tax rates in explaining the change in sectoral multipliers between 1963 and 1968. After that, the importance of consumption structure has been measured by the difference between a second hypothetical multiplier for a system with the 1963 technology and final demand structures, but with the 1968 tax rates and consumption patterns, (μ_C), and the first hypothetical multiplier (μ_T). The importance of the final demand structure has also been measured along the same lines, as the difference between a third hypothetical multiplier (μ_D) and the second (μ_C). Then, the importance of substitution between domestic and imported intermediary inputs has been measured as the difference between the actual fixprice multiplier for 1968 (μ_{68}) and the hypothetical multiplier for a system having a 1968 structure of taxation, consumption and final demand, but with a ratio between imported and domestically produced inputs, for each industry, at its 1963 level, (μ_M). Finally, the difference between μ_M and μ_D is taken as the measure of the residual effects of changes in technological coefficients which occurred between 1963 and 1968 as results of substitution between primary and non-primary inputs, substitution among non-primary inputs, technical progress, or changes in relative input prices.[9]

[8] In view of (4) and (10) the endogenous consumption coefficients can be written as:
$c_{ij} = \varepsilon_i \, b \left[(1 - t_w)\gamma_j + \eta(1 - t_\pi) \{1 - (1 + t_j) (\Sigma_k \alpha_{kj} + \beta_j) - \gamma_j\}\right].$

The results of the simulations are presented in Table 8, where the multiplier change between two consecutive years is analysed as described above. They show very clearly that the two main factors affecting the aggregate multiplier over the period have been taxation and import substitution. The effects of the former have been strongly negative between 1963 and 1970 — where taxation alone explains 64% of the fall in the multiplier — and strongly positive up to 1972 — where again this factor alone explain 78% of its increase — mainly due to the 1970 fiscal stringency and the 1972 tax cut.

Also, Table 8 shows that import substitution effects are negative throughout, except in the period 1970-71. Since the ratio of the endogenous consumption import and the total indirect import to the value of GNP increases in the periods 1963-1970 and 1971-1973 but decreases in the period 1970-71, these results are perfectly consistent with the view that an increase (or a decrease) in the import ratio would give rise to a decrease (or an increase) in the aggregate multiplier.

[9] The magnitudes of the tax, consumption, final demand, import substitution and technology effects, into which the sectoral and aggregate multipliers are analysed, are not independent of the order of simulation experiments being made. For example, if hypothetical multipliers μ'_C are first calculated on the basis of the 1963 technology, tax rates and final demands and the 1968 consumption pattern, the consumption effects $\mu'_C - \mu_{63}$ will generally be different from the effects calculated above at $\mu_C - \mu_T$. A similar observation was made by MOSAK (1942) for the income and substitution effect on consumer demand. He showed that the order of simulations does not significantly affect the magnitudes of these effects, provided that prices make very small change. Such observation was confirmed by varying the order of the simulations in an application of our model to Italy, where it was also found that the results of the simulations were practically unaltered if, in each simulation, only one factor was altered instead of more than one at the same time; see PROSPERETTI (1983) ch. III.

TABLE 8

SIMULATION ANALYSIS OF FIXPRICE MULTIPLIER CHANGES FOR THE U.K.

Period	Sector	Total Change	Tax Effect	Consumption Effect	Final Demand Effect	Import Substitution Effect	Residual Technological Effects
1963 to 1968	Agriculture	- .88	- .52	- .35	- .33	+ .09	+ .23
	Manufacturing	- 3.55	- .60	- .79	- .99	- .97	- .20
	Non-Manufacturing	- 1.79	-1.35	- .24	+ .66	- .28	- .58
	Services	- 2.82	-2.60	- .44	+ .29	- .24	+ .17
	Public Administration	+ .70	- .38	+ .65	+ .44	- .15	+ .14
	Total	- 8.36	-5.46	-1.16	+ .06	-1.55	- .25
1968 to 1970	Agriculture	- .26	- .28	+ .22	+ .11	+ .01	- .32
	Manufacturing	- 1.77	- .87	- .03	+ .35	- .98	- .24
	Non-Manufacturing	- 2.09	- .58	+ .05	-1.34	- .41	+ .19
	Services	- 1.67	- .76	- .78	+ .34	-1.24	+ .77
	Public Administration	+ 1.37	- .27	+ .87	+ .72	- .09	+ .14
	Total	- 4.40	-2.76	+ .33	+ .19	-2.69	+ .53
1970 to 1971	Agriculture	- .07	+ .13	- .09	- .12	- .03	+ .04
	Manufacturing	- 1.10	+ .08	+ .06	- .72	+ .81	-1.33
	Non-Manufacturing	+ .14	+ .25	- .14	+ .36	- .17	- .16
	Services	+ 2.11	+ .56	+ .28	+ .05	+ .06	+1.16
	Public Administration	+ .76	+ .07	- .03	+ .76	.00	- .04
	Total	+ 1.83	+1.08	+ .08	+ .33	+ .68	- .34
1971 to 1972	Agriculture	+ .13	- .10	- .11	.00	- .01	+ .35
	Manufacturing	- .12	+ .42	- .01	- .81	- .42	+ .70
	Non-Manufacturing	+ 1.56	+ .94	+ .06	+ .16	+ .13	+ .27
	Services	- .03	+ .94	- .01	+ .33	- .29	-1.00
	Public Administration	+ 1.14	+ .26	+ .02	+ .96	- .08	- .02
	Total	+ 2.68	+2.45	- .03	+ .63	- .68	+ .31
1972 to 1973	Agriculture	.00	- .05	- .03	.00	- .15	+ .23
	Manufacturing	- 1.92	- .15	- .66	+ .89	-2.88	+ .88
	Non-Manufacturing	.00	+ .29	- .37	+ .27	- .75	+ .56
	Services	- 1.35	+ .38	- .44	-1.12	-1.26	+1.09
	Public Administration	- 1.21	- .11	- .01	-1.20	- .40	+ .51
	Total	- 4.48	+ .36	-1.51	-1.16	-5.43	+3.26
1963 to 1973	Agriculture	- 1.08	- .82	- .36	- .34	- .09	+ .53
	Manufacturing	- 8.46	-1.12	-1.43	-1.22	-4.44	- .19
	Non-Manufacturing	- 2.18	- .45	- .64	+ .11	-1.48	+ .28
	Services	- 3.76	-1.48	-1.39	- .11	-2.97	+2.19
	Public Administration	+ 2.76	- .43	+1.50	+1.68	- .72	+ .73
	Total	-12.73	-4.33	-2.29	+ .05	-9.67	+3.51

Note: All figures multiplied by 10^2.

Finally, final demand, consumption and technology effects have been relatively less important up to 1972, but became of considerable magnitude in 1972-73. Thus we may conclude that the dynamics of the multiplier has been dominated up to 1972 by a policy variable (taxation), but that its fall in 1972 has been caused by changing structural features of the system and in particular by import substitution effects.

Turning now to consider the relevance of the various effects at the sectoral level, we can see how taxation has generally affected all sectors in the same direction. This is particularly interesting since for a part of the decade (1966-71) the government tried to stimulate manufacturing and penalise services via the well-known Selective Employment Tax (SET). Examination of our results for the period 1963-68 suggests, however, that while the second objective was fully attained, the total effect of direct and indirect taxation on the manufacturing sector was also negative.

On the technological side import substitution effects have analogously influenced the different sectors in a similar fashion, being negative in general and being of greater relevance for manufacturing and services than for the other sectors. Residual technological effects, on the other hand, although showing a varying pattern from year to year have been positive for all sectors, except manufacturing, over the whole period (1963-73). Among the largest is the effect on the service sector.

On the demand side, over the whole period, consumption effects have been favourable for public administration and unfavourable for the other sectors. It is seen that they have been particularly negative for services, clearly reflecting the stronger impact on this sector of the process of substitution in consumption of publicly-provided goods and services for those provided by the private sector. Final demand effects, on the other hand, show a varying pattern reflecting the changes in the mix, within final demands, among autonomous consumption, investment, export and government expenditure. Over the decade, however, they broadly tend to follow the pattern of the consumption effects.

V. A simulation analysis of the change in sectoral shares

Having analysed, in the last section, the influence of a number of factors on the value of sectoral multipliers, we now turn to analyse their influence on the changes in the ratios of sectoral multipliers to the total national income multiplier. This, as it was discussed above (see (19)), is equivalent to analysing the changes in sectoral shares in the total value added.

The method we have employed can be summarised as follows. Recalling that, for any year t,

$$y_t = \hat{v}_t \, (I - A_t)^{-1} \, E_t,$$

where $E_t = p_t \, \underset{\sim}{D}_t$, and $\hat{v}_t$ is the diagonal matrix of the sectoral value-added ratios, then the change in the sectoral income from t to t+1 will be given by:

$$\Delta y_t = \Delta H_t \, E_{t+1} + H_t \, \Delta E_t,$$

where $H_t = \hat{v}_t \, (I - A_t)^{-1}$.

But, as we did in section IV above, we can decompose the change in the augmented inverse H into the changes attributable to taxation, consumption structure, import substitution and other effects, i.e.

$$\Delta H = \Delta H_T + \Delta H_C + \Delta H_M + \Delta H_R,$$

where the suffixes have the known meaning, and ΔH_R is the change attributable to the residual factors.

Thus, for the i-th sector we may write:

$$\Delta y_i = (\Delta H_T \, E_{t+1})_i + (\Delta H_C \, E_{t+1})_i + \ldots + (\Delta H_R \, E_{t+1})_i + (H_t \, \Delta E_t)_i, \qquad (20)$$

where the suffix i attached to a vector indicates its i-th element, and the last term shows the portion of change which is attributable to changes in the scale and the structure of the final demand vector. Now the change in sectoral shares between the two years is

$$\Delta s_{ti} = \frac{y_{ti} + \Delta y_{ti}}{Y_t + \Delta Y_t} - \frac{y_{ti}}{Y_t},$$

where $Y_t = \Sigma y_{ti}$. It can be rewritten as

$$\Delta s_{ti} = \left(\Delta y_{ti} - \Delta Y_t \frac{y_{ti}}{Y_t}\right) \div Y_{t+1}$$

or, by (20) as:

$$\Delta s_{ti} = \Big[\Big((\Delta H_{Tt} E_{t+1})_i - u \Delta H_{Tt} E_{t+1} \frac{y_{ti}}{Y_t}\Big) + \ldots + \Big((\Delta H_{Rt} E_{t+1})_i - u \Delta H_{Rt} E_{t+1} \frac{y_{ti}}{Y_t}\Big) + \Big((H_t \Delta E_t)_i - u H_t \Delta E_t \frac{y_{ti}}{Y_t}\Big)\Big] \div Y_{t+1}$$

where u is the summation vector whose elements are all 1. This equation decomposes the change in sector i's share into effects attributable to taxation, consumption structure, import substitution, residual technolo-

gical and final demand effects. The results of such analysis of changes in the shares over the whole period (1963-73) is presented in Table 9: the most notable changes in the period are found in the manufacturing sector, the share of which is estimated to decrease by 3.51 points (against the actual decrease by 3.36 points), and in the public administration sector with an estimated increase of 4.03 points in its share (against the actual increase by 4.16 points).

TABLE 9

SIMULATION ANALYSIS OF SHARE CHANGES: THE U.K. 1963-1973

	Actual Change	Estimated Total Change	Taxation Effect	Consumption Effect	Final Demand Effect	Import Substitution Effect	Residual Technological Effect
Agriculture	− .600	− .540	− .238	− .077	− .441	+ .194	+ .021
Manufacturing	−3.360	−3.511	+ .096	− .216	−2.606	+ .085	− .870
Non-Manufacturing	+0.430	+ .406	+ .199	− .058	+ .317	− .028	− .025
Services	−0.630	− .382	− .123	− .245	− .331	+ .004	+ .313
Public Administration	+4.160	+4.028	+ .066	+ .596	+3.060	− .255	+ .561

Our results suggest that changing consumption and final demand patterns have been the principal factors affecting changes in the shares: the sum of the two effects accounted alone for 90.7% of the rise in the share of the public administration sector and for 80.7% of the fall in that of manufacturing. Residual technological effects were also important in both sectors, while the import substitution effects upon the sectors other than agriculture are all small. The taxation effects upon the manufacturing sector and that upon public administration are also small.

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