CENTER OF ECONOMIC RESEARCH

LECTURE SERIES

16.

# INDUSTRIALISATION AND CAPITAL REQUIREMENTS IN GREECE

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G. C. ARCHIBALD

Reader in Economics
The University of Essex, and
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*Opinions or value judgements expressed in this book are those of the author and do not necessarily represent those of the Center of Economic Research*

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# CENTER OF ECONOMIC RESEARCH

*The Center of Economic Research in Greece was established in the expectation that it would fulfill three functions: 1) Basic research on the structure and behaviour of the Greek economy, 2) Scientific programming of resource allocation for economic development and, 3) Technical-economic training of personnel for key positions in government and industry. Its financial resources have been contributed by the Greek Government, the United States Mission in Greece and the Ford and Rockefeller Foundations. The University of California at Berkeley participates in the process of selection of foreign scholars who join the Center's staff on an annual basis. It also participates in a fellowship program which supports research in Greece by American graduate students, as well as studies for an advanced degree in economics of Greek students in American Universities.*

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*Finally, one should emphasize that this is one more example of Greek-American cooperation, a pooling of human talent, funds and efforts, designed to promote the training of economists and to help in meeting Greece's needs in the field of economic development.*

*The final aim is eminently practical: to help in creating a better life for the Greek people.*

George Coutsoumaris, Director

# I. INTRODUCTION

1. There is an enormous amount of literature on investment criteria, a thorough survey of which would be beyond both the scope of this paper and its author's competence. Two particular points, however, will be taken up, first, the normative application of Chenery's «Patterns of Industrial Growth» [ 6 ], on which Papandreou [ 20 ] relied heavily, and, second, the use of capital:output coefficients, on which many people rely for planning purposes, in the light of inter-industry relationships.

2. It is widely believed that manufacturing is the sector which Greece should expand most, and must rely on for future prosperity, particularly since Greece is committed to the Common Market. Sometimes the argument advanced is that Japan and Italy both, like Greece, short of natural resources, have built prosperous manufacturing industries so that, by analogy, Greece must and can follow suit. This is not an argument: the Floridans and the Eskimos are short of natural resources too.

3. In fact, for an open economy, there is a peculiarly interesting and difficult planning problem, that of anticipating where comparative advan-

tage may be found in order to direct the pattern of resource accumulation appropriately. This strikes me as a remarkably intractable problem. A solution may, in principle, be provided by a complete programming model, such as that which Nugent [ 19 ] is constructing, but even that has its limitations. In particular, a change in the pattern of resource availability changes relative factor prices and, therefore, input coefficients (for primary inputs if not intermediate products); it is this in turn that leads to the change in possible product prices which is the source of comparative advantage. It is not easy to see how a programming model handles these changes; nonetheless, Nugent's model appears to offer more hope than any available alternative.

4. It is worth remembering the familiar proposition that rational policy will not aim at maximising trade, or even the gains from trade, but utility. In general, utility will not be maximised by the maximisation of either objective, and to take trade as a maximand is as foolish as to take it as a minimand (the self-sufficiency programme). *Assuming that world prices are independent* of Greek trading, utility is maximised by maximising the distance from the origin of the attainable frontier, so the problem is to find the pattern of investment which moves the frontier furthest from the origin. This familiar proposition may be simply illustra-

ted (but not solved!). In Figure 1, AB represents the Greek production frontier at time t, and LM the frontier attainable with trade. Production

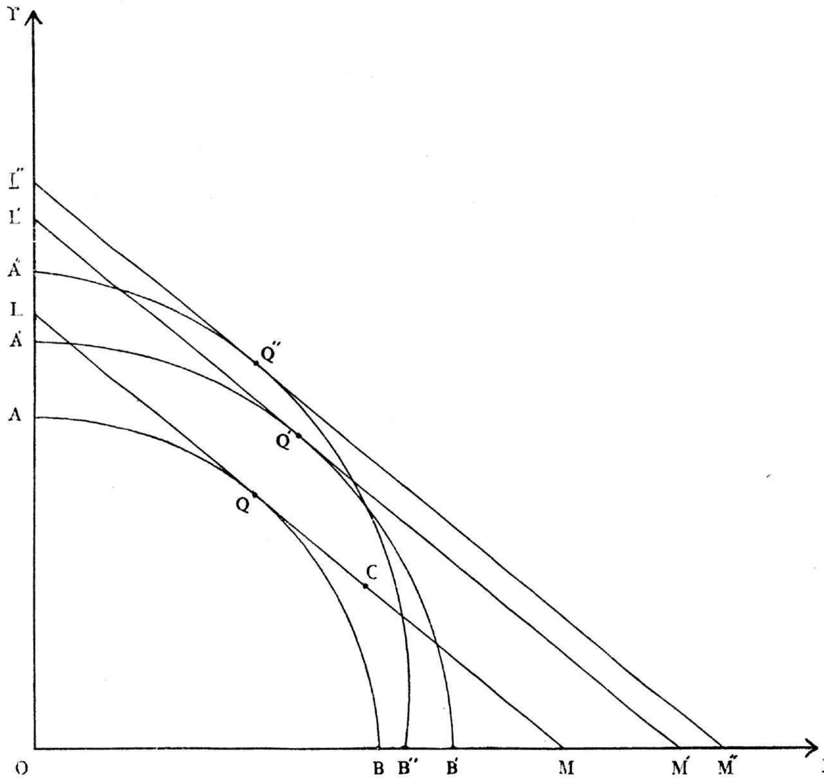


Figure 1.

is at Q, and we may suppose consumption to be at a point such as C. A proportionate expansion of the production frontier replaces AB with A'B', production at Q', and consumption somewhere on

Q′M′, superior to QM. Suppose, however, that by investing more heavily in Y than in X, the same total investment could move the frontier to A″B″. Production would be at Q″, and consumption in Q″M″, superior to Q′M′. Note that *trade* at Q″ might be greater or less than at Q′, and similarly at Q′ greater or less than at Q, depending on the shape of the frontiers and of the consumption expansion path. Clearly trade may increase or decrease, *and so may the gains from trade.*

# II. PATTERNS OF INDUSTRIAL GROWTH [1]

1. *The heart of Chenery's impressive paper* is the demonstration that, in a cross-section study, the degree of industrialisation is closely associated with income per capita. The question is whether his regression line should be taken as a norm, so that a country which is below it should consider reaching it as a rational object of policy. There seem to be some serious objections to this interpretation.

2. The first is in the interpretation of a regression equation. Chenery fits

$$\log V_i = \log B_{i0} + B_{i1}\log Y + B_{i2}\log N$$

where $V_i$ is value added per capita in the i'th sector, Y national income, and N population. (See [ 6 ] pp. 630 - 637, and particularly Figure 2, p. 637). Here income is the independent variable. The normative interpretation involves the belief that the independent variable can be increased by increasing the dependent variable. This is an illegitimate use of regression results. Nor-

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1. I am indebted to my colleagues in the Research Seminar at the Center of Economic Research, and particularly to Professor Jean Crockett, for many of the points discussed here.

mative application appears, as a colleague of mine remarked, to imply the view that, to get rich, you should spend like a rich man. Reversing the roles of dependent and independent variables lends no more support to this view than does common sense.

3. If a structure is not identified, reduced-form coefficients may, if they fit well, be used for forecasting purposes (so long, at least, as the — unknown — underlying structure does not change). When the structural parameters are unknown, however, it is scarcely possible to predict the consequences of policy changes. This may be illustrated by the familiar case of an underidentified supply and demand model (see Working [ 23 ]). Suppose that both the quantity demanded and the quantity supplied of some commodity are functions of income as well as price, and that we have estimated the reduced form coefficients. If we can forecast next year's income, we can forecast price and quantity for this commodity. What we cannot do is predict the effects of, say, direct and indirect taxes (policy variables) because they affect producers and consumers differently, and we know nothing about the separate behaviour of each. Now, the attempt to use Chenery's study for normative purposes faces something like this difficulty. Income, in his regression, is operating on both the demand and the supply sides. On the latter, it

serves as a proxy for capital accumulation, natural resources, skill of the labour force, etc., — as Chenery himself points out. It is not obvious how one is to proceed from such a regression to policy.

4. The difficulties inherent in proceeding from a cross-section analysis to a time-series application are obvious. Several of them are discussed by Chenery. What we may notice here is that Chenery's observations are the result not only of «natural» growth, but also of past policies. If a country has deliberately neglected comparative advantage in the pursuit of self-sufficiency, industrialising behind tariff walls and the like, it will be found closer to Chenery's regression line than it «should». (The belief that the regression line represented a norm which a country should endeavour to reach would encourage autarchic policies.) Furthermore, if many countries have industrialised behind barriers, as common observation suggests to be the case, the regression line is biased: it probably has a smaller slope and a larger intercept than the «comparative advantage» line would have.[1] We may accept the proposition that, in a

1. By «comparative advantage» line, I mean the regression line we should have obtained in a free-trade world. That the real-world line is likely to be steeper can be seen as follows. The country which industrialises with protection gets less increase in income and more increase in industry than it would in a free-trade

free-trade world, the association between industrialisation and income would still appear, but it would be much less strongly marked: without protection, the British agricultural sector would be smaller and the New Zealand larger. Finally, notice that, in a world of restrictive trade policies, the domestic price of manufactures will be above the world price in a country which is protecting manufacturing, with the result that the contribution of its (inefficient) manufacturing sector to national income will be overvalued.[1]

5. All things considered, it seems most unsafe to use Chenery's regression line as a norm. There is no evidence that, if a country is below it, comparative advantage is to be gained by reaching it; and there is no evidence that, once on it, the best way of increasing income is to plan for an industrial output characteristic of countries higher up on it. None of this, of course, detracts from Chenery's work: it is no fault of his that observations

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world. At the same time, the smaller volume of trade prevents the countries whose comparative advantage *is* in industry from enjoying as much industry *or* income as they would in a free trade world. If we indentify the latter group with the richer countries, we get the bias described in text, but this indentification is inaccurate: hence the «probably».

1. I owe this point to Mr. Leonard S. Miller. Whether protection increases the total value of manufactured goods *consumed* depends on the elasticity of demand; but it must increase the price as well as the quantity of domestic output.

of other countries, in an imperfect world, cannot solve for any one country the problem, discussed in I.3 and 4 above, of devining where its future comparative advantage may lie. This remains a most intractable problem.

# III. INTER-INDUSTRY RELATIONS[1]

1. Capital:output ratios are widely used by planners, and in several ways. Inspection of capital:output ratios suggests which sectors offer the biggest return on scarce capital (see Ellis, Psilos, and Westebbe [ 10 ]). If it is known what outputs are wanted, capital:output ratios can be used to calculate capital requirements so that the feasibility of alternative programmes may be studied (Papandreou [ 20 ]). In fact, the use of capital:output ratios for the selection of investment projects is in general wrong, although in some special cases it may be a convenient and not too inaccurate ready-reckoner. But this has been very widely discussed,[2] and the arguments need not be

1. I am heavily indebted to Mr. John Deprès for his help with this section. He not only supervised most of the computations but also made many valuable comments and suggestions in the course of the work. For an authoritative treatment of many of the points discussed here, see Chenery [5].

2. The capital:output ratio, or rate of capital turnover, was advocated as an investment criterion by Buchanan [2] in particular, and also by Polak [21]. Kahn [14], in an excellent review of the problem of investment criteria, showed that minimising the capital:output ratio would only in certain cases lead to the optimal choice, i.e. the allocation that maximises Social Marginal Product. Later work has mainly been concerned with the SMP criterion. Thus Chenery [4] has developed some methods of calculation, and Leibenstein has argued, i.a., that SMP is in-

rehearsed here. What concerns me is that, in the case of both the references cited, the capital:output coefficients used have been the direct coefficients, and a moment's thought will show that this leaves a lot to be desired. Suppose that the capital:output ratio for manufacturing is 0.7. Now recall that to produce a unit of manufactured product, it is necessary to obtain inputs from other sectors —raw materials, power, etc. To increase the outputs of these sectors in turn requires investment. So the total capital requirement for an additional unit of output in manufacturing is not 0.7, but a larger number. How much larger depends on the inter-industry requirements of manufacturing, and the capital requirements of the other sectors involved. But this is not all. An increase in the outputs of other sectors to provide inputs for manufacturing in turn requires inputs from other sectors, involving yet further capital requirements. Clearly the total capital requirements for a unit increase of output in, say, manufacturing, cannot be discovered without the use of an Input-Output Table (or, rather, its inverse).

2. The rest of this section is by way of being

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adequate as an investment criterion if population growth, skills, etc., are not independent of the choice of investment projects (see Leibenstein [15] and [16], and Galenson and Leibenstein [12]; for criticism, see Eckstein [9], Bator [1], and Sen [22]). Further applications will be found in McKean [18], and Hirschleifer, de Haven and Milliman [13].

a cautionary tale. Whatever we may think of the comparison of capital: output ratios as an investment criterion, if it is to be done, it must take account of inter-industry requirements. And it is clear that feasibility studies must do so likewise. An economy's ability to produce a certain collection of goods for final use depends on its ability to produce (or import) the intermediate inputs as well as the final product itself, and the capital requirements for any final uses are obviously those for all the required outputs. Armed with an Input-Output Table for Greece, and a vector of direct capital coefficients, we can easily calculate total capital requirements, direct and indirect, and shall get some unpleasant shocks. Not only are total requirements naturally much larger than direct requirements, but also the ranking of industries according to the size of their capital requirements is changed. The reason for this is intuitively clear: one industry may require inputs from industries with large coefficients, while another, with a larger direct coefficient, may require inputs mainly from industries with low coefficients, and thus have smaller indirect requirements. *Thus the use of direct coefficients to determine the sectors in which scarce capital goes furthest is a thoroughly unsafe procedure.* In fact, the matter goes even further than this. It turns out that there is a close association between the size of a direct coefficient and its proportion of the total coefficient. The intuitive argument is simply that, the larger the direct coefficient, the less important proportionally are the indirect requirements, and vice-versa. This means that if the choice of sectors for expansion is determined from the direct coefficients, it will not only be wrong, it will also be biased (substantially) against the industries with larger direct coefficients. This suggests, what is in fact the case, that the variance of a vector of total coefficients is less than the variance of the corresponding vector of direct coefficients.

In fact, we have more than one vector of direct coefficients to choose from (the alternative methods of estimation are discussed below), and this leads to a second unpleasant shock. These vectors agree in their ranking of sectors: the vectors of total coefficients do not. The reason is intuitively clear: the total coefficients are functions, in general, of all the direct coefficients. If, and only if, the direct vectors varied only by a scalar could one be sure that the ranking would be preserved. This means that the ranking of the total coefficients is sensitive to the absolute values of the direct coefficients as well as to their ranking. Thus even the (mistaken) programme of using the total coefficients to suggest the most productive uses of scarce capital is crucially dependent upon the accuracy with which the direct coefficients are estimated. We have three vectors of direct coefficients which agree in ranking but differ in absolute value. This is obviously a matter that requires further attention.

3. Some other rather alarming points will emerge as we proceed. It should be emphasized now that much of what follows should be taken as illustrative only, since the Input-Output Table presently available is not very reliable.[1] Since much of the discussion of planning in Greece has taken place in terms of very large aggregates, and since three independently estimated vectors of direct coefficients are available at approximately the same level of aggregation, the matrix was first aggregated to 5×5 and then inverted.[2] This is crude, but consistent with some of the discussion, and at least serves to illustrate some of the points made above. The Input-Output Coefficient Matrix is

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1. I am enormously indebted to the generosity of Mr. J. Nugent in making this table available to me, and in many other matters besides. The unreliability of the Table is no reflection on anyone: to get it, Nugent adjusted the 1954 Table, prepared by Mr. Geronimakis of the National Accounts Division of the Ministry of Coordination, to 1961 as best he might. He converted the Table from Sellers' Prices to Purchasers' Prices excluding Indirect Taxes. When Nugent's work is completed, and the new Input-Output Table at present being prepared by the Ministry of Coordination is available, it will be possible to place some reliance on the results of the computations described here.

2. By the Gauss-Seidel method. See Chenery and Clark *[7]*, and Evans *[11]*. It converged at four places of decimals within four iterations.

presented in Table III.1, the Inverse Matrix in Table III.2, and the vectors of direct[1] and total capital requirements in Table III.3.a.

The method of calculating the total requirements is simplicity itself. The i'th column of the inverse matrix gives the total requirements for a unit increase in final demand in the i'th industry. Thus if we denote a total capital coefficient by $K_i^*$ and a direct one by $K_i$, we have simply

$$K_i^* = \sum_{j=1}^{n} r_{ji} K_j$$

Here $K_i$ is included in the multiplication and summation because a unit of final demand from the i'th industry normally requires, thanks to intra-industry demands, more than one unit of output in the i'th industry. Thus $K_i$ is to be multiplied by $r_{ii}$ rather than by unity.[2]

1. Two of the vectors of direct coefficients, Papandreou's and the Projection set, were originally expressed in terms of value added. They were converted to output by multiplying them by the ratio of National Accounts Value Added to Nugent's Gross Output. The adjustments are further described in III.7 below.

2. The fact that some of the ratios were originally expressed in terms of value added may cause confusion and lead to a suspicion that I am double counting. Write the capital: value added ratio K:V. To convert to output terms, it is multiplied by V:X, yielding our $K_i$. Now $r_{ii}$ is the ratio of output required per unit of final demand, or X:Y (Y = 1). Hence we have, for the i'th element in $K_i^*$,

$$\frac{K}{V} \cdot \frac{V}{X} \cdot \frac{X}{Y} = K : Y,$$

which is what is wanted. For a formal treatment of the relationships, see Lange [17].

TABLE III.1

1961 GREEK INPUT-OUTPUT COEFFICIENT MATRIX: AGGREGATED TO $5 \times 5$

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. Electricity and Gas | .0840 | .0149 | .0013 | .0162 | .0075 |
| 2. Mining | .0905 | | | .0119 | .0001 |
| 3. Agriculture | | | .2743 | .1062 | .0017 |
| 4. Manufacture | .1134 | .1500 | .0890 | .3511 | .0807 |
| 5. Services | .1702 | .3250 | .1060 | .2156 | .0946 |

Source: Nugent [19].

TABLE III.2

INVERSE OF $5 \times 5$ COEFFICIENT MATRIX

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. Electricity and Gas | 1.0988 | .0251 | .0078 | .0329 | .0118 |
| 2. Mining | .1025 | 1.0058 | .0034 | .0225 | .0030 |
| 3. Agriculture | .0386 | .0446 | 1.4135 | .2409 | .0243 |
| 4. Manufacture | .2592 | .2975 | .2248 | 1.6373 | .1478 |
| 5. Services | .3083 | .4400 | .2208 | .4305 | 1.1412 |

It will be noticed that each total coefficient obtained in this manner gives the *total requirement, irrespective of its source, for an additional unit of final demand from one sector, final demand in the other sectors being held constant* (but output, of course, increasing sufficiently to meet intermediate demands). It is thus a total capital: final demand coefficient rather than a literal capital:output coefficient. This, on the assumption that it is final demand that is interesting, is the right number to present, but the literal capital:output coefficient ratios are easily obtained if they are wanted. The inter-industry requirements for a unit increase in the i'th industry's output instead of its final demand are found by deflating the i'th column of the inverse matrix by $r_{ii}$. Thus the total capital requirement can be obtained merely by dividing $K_i^*$ by $r_{ii}$ ($K_i^*$ is obtained by multiplying two vectors; $r_{ii}$ is a scalar, and scalar multiplication of vectors is commutative).

It will also be noticed that nothing has been done here to separate imports. Table III.1 is in fact the $[A + M]$ matrix, and the inverse in Table III.2 is thus $[I - \{A + M\}]^{-1}$. This means that the total capital requirements calculated from this matrix are overstatements: input flows which are imported have been treated as though they had to be domestically produced, and the $K_i^*$ therefore include investments which would in fact

TABLE III.3.a

DIRECT AND TOTAL COEFFICIENTS

| Sectors | Direct Coefficients | | | Total Coefficients | | | Ratios of Total to Direct Coefficients | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1)[a] | (2)[b] | (3)[c] | (4) | (5) | (6) | (7) | (8) | (9) |
| 1. Electricity and Gas | 4.7 | 4.0 | 5.0 | 6.5 | 5.4 | 6.3 | 1.4 | 1.3 | 1.2 |
| 2. Mining | 9 | 1.0 | 1.0 | 2.7 | 2.3 | 2.0 | 3.0 | 2.2 | 1.9 |
| 3. Agriculture | 1.5 | 1.7 | 1.2 | 3.0 | 3.0 | 2.2 | 2.0 | 1.8 | 1.8 |
| 4. Manufacturing | .3 | .7 | 0.5 | 2.6 | 2.5 | 1.8 | 7.6 | 3.8 | 4.0 |
| 5. Services | 3.5 | 2.0 | 1.4 | 4.1 | 2.5 | 1.8 | 1.2 | 1.2 | 1.3 |

(a) From Nugent [19].
(b) From Papandreou [20] (adjusted).
(c) Projection set, from Ministry of Coordination (adjusted).

TABLE III.3.b

SECTOR RANKING OF DIRECT AND TOTAL CAPITAL COEFFICIENTS[1]

| Sectors | Ranking of Direct Coefficients | | | Ranking of Total Coefficients | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| 1. Electricity and Gas | 1 | 1 | 1 | 1 | 1 | 1 |
| 2. Mining | 4 | 4 | 4 | 4 | 5 | 3 |
| 3. Agriculture | 3 | 3 | 3 | 3 | 2 | 2 |
| 4. Manufacturing | 5 | 5 | 5 | 5 | 4 | 4 |
| 5. Services | 2 | 2 | 2 | 2 | 3 | 5 |

1. Ranked before rounding off coefficients.

have to be made by foreign suppliers. How serious this error is depends, of course, on the size of the import coefficients $m_{ij}$. We do not know these, but present below some estimates, together with their effect on calculated capital requirements.

5. The results of operating with the inverse matrix of Table III.2 are exhibited in Tables III.3.a and .b. They are easily interpreted in the light of what has already been said. The ratios of the total to the direct coefficients are shown in columns (7), (8) and (9) of Table III.3.a, which give some notion of the magnitude of the errors likely to be made when direct coefficients are used for planning purposes. It will be noticed that, as was suggested above, the dispersion in columns (4), (5) and (6) is less than that in columns (1), (2) and (3) and, what comes to the same thing, that the ratios of columns (7), (8) and (9) are negatively associated with the magnitudes of the direct coefficients.

Table III.3.b shows the sensitivity of our calculated total coefficients to absolute differences in the estimates of direct coefficients that are used. All three vectors of direct coefficients agree in ranking: none of the corresponding vectors of total coefficients agree! The position of manufacturing may be particularly noticed. *It is the «best buy» according to all three estimates of direct coefficients, but according to only one of the corresponding vectors of to-*

*tal coefficients*. In view of the importance attached to manufacturing in Greek development planning, it is obviously of considerable importance to discover whether the same sort of thing happens to individual manufacturing sectors when we disaggregate, and whether it continues to happen when we make some correction for imports. We may now turn to these topics.

6. Since the available Input-Output Table is 15 × 15, it does seem more sensible to work with this and to disaggregate (or re-estimate) the direct capital coefficients than to aggregate the matrix to fit the coefficients. To facilitate hand computations, the matrix was triangulated.[1] It then took the following form: Sectors 1 through 10 have no current requirements from the remaining sectors [ O ], although they provide inputs to those sectors [ D ]. Those sectors (Clothing, Construction Materials, Transport Equipment, Construction, and Tourism) have negligible inputs[2] from each other [ O′ ]. Thus it was only necessary

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1. The Gause-Seidel method was again used. Since the matrix was triangulated, one iteration sufficed to generate each column of the inverse. Computation, following the format of Chenery and Clark *[7]*, proved surprisingly quick and easy. The matrix did not triangulate perfectly: the above-diagonal coefficients that were replaced by zeroes accounted for approximately 3.1% of gross output.

2. There are in fact two coefficients in [O′] which were used later in estimating capital requirements, with negligible effects.

to invert the $10 \times 10$ [ A ]. The $15 \times 15$ Coefficient Matrix is presented in Table III.4 and the $10 \times 10$ inverse in Table III.5.

$$\begin{array}{c} 1 \\ \vdots \\ 10 \\ 11 \\ \vdots \\ 15 \end{array} \left[\begin{array}{c|c} \begin{array}{c} \\ A \\ \\ \end{array} & \begin{array}{c} \\ D \\ \\ \end{array} \\ \hline O & O' \end{array}\right]$$

As was noted above, however, imports have not been separated, so that Table III.5 is in fact $[\, I - \{A + M\}]^{-1}$. Separate A and M Flow Tables do not exist, so that any attempt to separate the two must be based on some fairly arbitrary allocation of imports. One such arbitrary allocation has been made, and the inverse computed, largely for illustrative purposes: we can at least see if any conclusions based on the use of Table III.5 need to be radically revised. Domestically produced and imported inputs were separated in a crude and simple manner. The initial information was the vector of imports classified by producing sector (Nugent). It was assumed that the imports are distributed proportionately between intermediate uses and final demand. Thus for each sector we calculate $M_i/Z_i$, the proportion of imports in to-

to invert the $10 \times 10$ [ A ]. The $15 \times 15$ Coefficient Matrix is presented in Table III.4 and the $10 \times 10$ inverse in Table III.5.

$$\begin{array}{r} 1 \\ \vdots \\ 10 \\ 11 \\ \vdots \\ 15 \end{array}\left[\begin{array}{c|c} A & D \\ \hline O & O' \end{array}\right]$$

As was noted above, however, imports have not been separated, so that Table III.5 is in fact $[I - \{A + M\}]^{-1}$. Separate A and M Flow Tables do not exist, so that any attempt to separate the two must be based on some fairly arbitrary allocation of imports. One such arbitrary allocation has been made, and the inverse computed, largely for illustrative purposes: we can at least see if any conclusions based on the use of Table III.5 need to be radically revised. Domestically produced and imported inputs were separated in a crude and simple manner. The initial information was the vector of imports classified by producing sector (Nugent). It was assumed that the imports are distributed proportionately between intermediate uses and final demand. Thus for each sector we calculate $M_i/Z_i$, the proportion of imports in to-

TABLE III.4

15 × 15 COEFFICIENT MATRIX

| Sectors | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Tobacco | .1276 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .0107 |
| 2. Textiles | .0114 | .1517 | 0 | .0060 | .0175 | 0 | .0004 | 0 | .0092 | 0 | .3377 | .0158 | .0071 | .0077 | 0 |
| 3. Electricity and Gas | .0011 | .0148 | .0825 | .0013 | .0179 | .0146 | .0143 | .0254 | .0072 | 0 | .0171 | .0403 | .0200 | .0076 | 0 |
| 4. Agriculture | .3861 | .2124 | 0 | .2551 | .1872 | 0 | .0541 | 0 | .0016 | 0 | 0 | 0 | 0 | 0 | .1441 |
| 5. Chemicals | 0 | .0198 | .0065 | .0556 | .0819 | .0819 | .0043 | 0 | .0029 | .0076 | .0237 | .0061 | .0194 | .0128 | 0 |
| 6. Mining | 0 | 0 | .0815 | 0 | .1361 | 0 | 0 | .0167 | .0001 | 0 | 0 | .1870 | .0037 | .0525 | 0 |
| 7. Manufacturing | .0186 | .0338 | .0147 | .0083 | .0439 | .0295 | .1878 | .0470 | .0332 | .0029 | .0090 | .0721 | .0797 | .1613 | .0144 |
| 8. Metallurgy | 0 | 0 | 0 | 0 | 0 | 0 | .1174 | .3370 | 0 | 0 | 0 | 0 | .1292 | .0191 | 0 |
| 9. Services | .1039 | .2079 | .1651 | .1027 | .2548 | .3151 | .1347 | .1511 | .0917 | .1270 | .3394 | .1276 | .1012 | .1742 | .2911 |
| 10. Petroleum Refining | 0 | .0064 | .0611 | .0021 | .0098 | .0072 | .0056 | .0105 | .0162 | .0146 | .0001 | .0358 | .0157 | .0056 | 0 |
| 11. Clothing | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12. Construction Materials | 0 | 0 | 0 | 0 | 0 | 0 | .0012 | 0 | 0 | 0 | 0 | 0 | .0233 | .1013 | 0 |
| 13. Transport Equipment | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14. Construction | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15. Tourism | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Source: Nugent [19].

tal supply, and a new A matrix is obtained by multiplying each row of Table III.5 by $M_i/Z_i$. A matrix of imports coefficients M* (* to denote «calculated, not observed») is similarly obtained by multiplying each row of III.5 by $1 - \frac{M_i}{Z_i}$, and the import coefficient for each sector is the column sum of M*. The $10 \times 10$ inverse matrix, which we might write as $[I - \{(A + M) - M^*\}]^{-1}$, is given in Table III.6 and the import coefficients in Table III.8. (For convenience, we shall refer henceforth to results obtained using the inverse in Table III.5 as Version I, and to those obtained using Table III.6 as Version II.)

In both Versions, total capital coefficients are calculated in the same way. For the first ten sectors, $K_i^*$ is calculated exactly as before. For the remaining five, however, a different procedure is required. Consider some sector j $(j > 10)$. The column of coefficients from the sub-matrix D gives the input requirements of j from sectors 1 through 10. Meeting these requirements involves the usual inter-industry flows, and investments, in those sectors. The requirements, however, are in terms of output, not final demand, so the capital coefficients of sectors 1 through 10 must be appropriately deflated (see III.3 above). Writing

$$\overline{K}_i^* = \frac{K_i^*}{r_{ii}} \tag{6.1}$$

## TABLE III.5

## INVERSE OF TRIANGULATED COEFFICIENT MATRIX

(Version I)

| Sectors | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Tobacco | 1.1462 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2. Textiles | .0182 | 1.2118 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3. Electricity and Gas | .0017 | .0199 | 1.0917 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4. Agriculture | .6616 | .3814 | 0 | 1.3780 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5. Chemicals | .0544 | .0664 | .0104 | .1122 | 1.1992 | 0 | 0 | 0 | 0 | 0 |
| 6. Mining | .0013 | .0032 | .0990 | .0024 | .0254 | 1.000 | 0 | 0 | 0 | 0 |
| 7. Manufacturing | .0540 | .0849 | .0833 | .0297 | .0966 | .0535 | 1.3399 | 0 | 0 | 0 |
| 8. Metallurgy | .0228 | .0359 | .0353 | .0126 | .0410 | .0226 | .5684 | 2.2178 | 0 | 0 |
| 9. Services | .2463 | .3750 | .2626 | .2016 | .3791 | .3710 | .3035 | .3816 | 1.1045 | 0 |
| 10. Petroleum Refining | .0094 | .0244 | .1033 | .0106 | .0268 | .0193 | .0260 | .0418 | .0245 | 1.0209 |

TABLE III.6

INVERSE

(Version II)

| Sectors | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Tobacco | 1.1463 | | | | | | | | | |
| 2. Textiles | .0154 | 1.1788 | | | | | | | | |
| 3. Electricity and Gas | .0016 | .0190 | 1.0899 | | | | | | | |
| 4. Agriculture | .5986 | .3362 | 0 | 1.3425 | | | | | | |
| 5. Chemicals | .0389 | .0488 | .0082 | .0863 | 1.1575 | | | | | |
| 6. Mining | .0008 | .0025 | .0890 | .0016 | .0221 | 1.0000 | | | | |
| 7. Manufacturing | .0352 | .0555 | .0234 | .0185 | .0634 | .0363 | 1.2312 | | | |
| 8. Metallurgy | .0062 | .0098 | .0041 | .0033 | .0112 | .0065 | .2179 | 1.5083 | | |
| 9. Services | .2201 | .3357 | .2354 | .1799 | .3436 | .3534 | .2189 | .2509 | 1.1010 | |
| 10. Petroleum Refining | .0058 | .0160 | .0724 | .0068 | .0178 | .0134 | .0129 | .0202 | .0181 | 1.0148 |

the total capital requirements for sector j are

$$K_j^* = K_j + \sum_{i=1}^{10} d_{ij}\,\overline{K}_i^* \qquad (6.2)$$

(where the $d_{ij}$ are the appropriate coefficients from D in Table III.4).[1]

7. Before discussing the results, something more should be said about the vectors of direct capital coefficients. Both Papandreou and Nugent adopted the same basic technique, and the differences in method appear to be innocuous. The procedure is to obtain several incremental ratios $K_{it}$ from

$$K_{it} = \frac{\sum_{t-4}^{t-1} I}{Y_t - Y_{t-4}}$$

and then to average them, obtaining

$$K_i = \frac{1}{n} \sum_{n} K_{it}$$

The differences between Papandreou and Nugent are as follows:

---

1. In the case of the two sectors, Transport Equipment and Construction, that had non-zero coefficients in [O'] (inputs from Construction Materials), these coefficients were merely multiplied by the partial coefficient $K_{12}$ for Construction Materials, and the product added to the sectors' other capital requirements. This is not strictly correct, but the quantities involved are negligible.

(i) The former used Value Added for Y, the latter Gross Output.

(ii) Papandreou takes his first observation two years earlier than Nugent, and his last one year earlier.

Further differences were introduced during the calculations performed here. In the first place, Papandreou worked at the $5 \times 5$ level, and some of the elements in the 15 element vector of coefficients labelled Papandreou in Table III.7 were *in fact constructed for the purpose*. The main adjustment required was the disaggregation of manufacturing, which was done by multiplying Nugent's coefficient for each manufacturing sector by a constant, the ratio of Papandreou's coefficient for total manufacturing to Nugent's. Thus it was assumed that the Papandreou-coefficients for individual manufacturing sectors would stand in the same proportion as Nugent's. (It was necessary to disaggregate Papandreou's Primary Production coefficient in the same way between Agriculture and Mining.) The Papandreou-coefficients had, of course, first been rounded by him, and, secondly, multiplied by the ratio of value added to gross output. This last point may be of some importance, since the ratio of value added to gross output was that for a single year, 1961. In so far as the differences are due to rounding, disaggregation, and conversion from value added to gross output, however, they are not very interesting. What is interesting is the fact that value added and gross output do not have either the same trend or the same pattern of first-differences, and this will lead to different results according as Papandreou's or Nugent's method is adopted. The first two columns of Table III.7.a exhibit the two sets of direct coefficients. It will be noticed that in the case of sectors 11 through 15, which are not in the inverse matrix, only one set of direct coefficients (Nugent's) was used — the only set available. It did not seem to be worth repeating the disaggregation procedure. If alternative sets of estimates are available, all that is required is five applications of equation (6.2) with alternative values of $K_j$.

The Projection Set of direct coefficients, like Papandreou's, was at a high level of aggregation and in terms of value added. It was therefore subjected to the same manipulations to generate an output coefficient vector at the desired level of aggregation. The Projection Set differs from both Papandreou and Nugent in that, while it was based on observations of incremental capital: value added ratios, the coefficients are larger or smaller than the observed ratios according to (a) the direction of change in the observed ratios, and (b) some expectations about future developments. Thus the agriculture coefficient was increased, both because the ratio does seem to have been increasing, and because it is believed that the investments with the highest return have already been made.[1] Similarly, the manufacturing coefficients were decreased on the grounds, partly of observed trends, and partly, I should judge, of mere wishful thinking. In fact, however, the Projection Coefficients do not differ greatly from those of either Papandreou or Nugent.

8. The results of Version I are exhibited in Table III.7, direct and total coefficients and their ratios in III.7.a, and ranking in III.7.b. The results are broadly similar in kind to those obtained with the 5 × 5, but call for some comment. Some of the ratios in columns (7), (8) and (9) of III.7.a are striking indeed. The effects on estimated capital requirements of taking into account interindustry requirements are substantial in nearly all cases, but dramatic in the cases of Clothing, Construction, and Tobacco. On the other hand, Services and Petroleum Refining are not much changed because they have very small domestic intermediate inputs, and the ratio for the Electricity

1. Casual observation of the behaviour of agricultural productivity in developed countries in recent years suggests that the projected increase in the agricultural coefficient may be quite wrong. I certainly do not think that it should be accepted without further enquiry. The effects of education on agricultural productivity can be very important, and a more skilled labour force will make better use of capital.

## TABLE III.7.a
## DIRECT AND TOTAL CAPITAL COEFFICIENTS
(Version I)

| Sectors | Direct Coefficients | | | Total Coefficients | | | Ratios of Total to Direct Coefficients | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) a | (2) b | (3) c | (4) | (5) | (6) | (7) | (8) | (9) |
| 1. Tobacco | .13 | .25 | .17 | 2.07 | 2.04 | 1.47 | 15.9 | 8.2 | 8.4 |
| 2. Textiles | .35 | .67 | .47 | 2.47 | 2.46 | 1.79 | 7.1 | 3.7 | 3.8 |
| 3. Electricity and Gas | 4.74 | 4.04 | 5.05 | 6.25 | 5.20 | 6.09 | 1.3 | 1.3 | 1.2 |
| 4. Agrictulture | 1.50 | 1.69 | 1.25 | 2.84 | 2.88 | 2.10 | 1.9 | 1.7 | 1.7 |
| 5. Chemicals | .48 | .91 | .64 | 1.96 | 2.01 | 1.41 | 4.1 | 2.2 | 2.2 |
| 6. Mining | .90 | 1.02 | 1.02 | 2.22 | 1.84 | 1.59 | 2.5 | 1.8 | 1.6 |
| 7. Manufacturing | .43 | .83 | .58 | 1.82 | 2.08 | 1.45 | 4.2 | 2.5 | 2.5 |
| 8. Metallurgy | .31 | .60 | .42 | 2.03 | 2.13 | 1.48 | 6.5 | 3.6 | 3.5 |
| 9. Services | 3.45 | 2.03 | 1.40 | 3.82 | 2.26 | 1.56 | 1.1 | 1.1 | 1.1 |
| 10. Petroleum Refining | .31 | .58 | .41 | .31 | .60 | .42 | 1.0 | 1.0 | 1.0 |
| 11. Clothing | .17 | .17 | .17 | 2.32 | 1.83 | 1.38 | 13.8 | 10.8 | 8.2 |
| 12. Construction Materials | .65 | .65 | .65 | 1.96 | 1.72 | 1.55 | 3.0 | 2.7 | 2.4 |
| 13. Transport Equipment | .26 | .26 | .26 | 1.15 | 1.04 | .85 | 4.4 | 3.9 | 3.2 |
| 14. Construction | .14 | .14 | .14 | 1.38 | 1.15 | .90 | 9.8 | 8.2 | 6.4 |
| 15. Tourism | .55 | .55 | .55 | .91 | .92 | .82 | 1.7 | 1.7 | 1.5 |

(a) From Nugent [19]. (b) Sectors 1 to 10, from Papandreou [20], adjusted.
(c) Sectors 1 to 10, Projection Set, adjusted.

TABLE III.7.b

SECTOR RANKING OF DIRECT AND TOTAL CAPITAL COEFFICIENTS[1]

| Sectors | Ranking of Direct Coefficients | | | Ranking of Total Coefficients | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| 1. Tobacco | 15 | 13 | 13 | 7 | 7 | 8 |
| 2. Textiles | 9 | 7 | 9 | 4 | 3 | 3 |
| 3. Electricity and Gas | 1 | 1 | 1 | 1 | 1 | 1 |
| 4. Agriculture | 3 | 3 | 3 | 2 | 2 | 2 |
| 5. Chemicals | 7 | 5 | 6 | 9 | 8 | 10 |
| 6. Mining | 4 | 4 | 4 | 6 | 9 | 4 |
| 7. Manufacturing | 8 | 6 | 7 | 11 | 6 | 9 |
| 8. Metallurgy | 10 | 9 | 10 | 8 | 5 | 7 |
| 9. Services | 2 | 2 | 2 | 3 | 4 | 5 |
| 10. Petroleum Refining | 11 | 10 | 11 | 15 | 15 | 15 |
| 11. Clothing | 13 | 14 | 14 | 5 | 10 | 11 |
| 12. Construction Materials | 5 | 8 | 5 | 10 | 11 | 6 |
| 13. Transport Equipment | 12 | 12 | 12 | 13 | 13 | 13 |
| 14. Construction | 14 | 15 | 15 | 12 | 12 | 12 |
| 15. Tourism | 6 | 11 | 8 | 14 | 14 | 14 |

1. Ranked before rounding off coefficients.

sector is fairly small for a quite different reason —its direct coefficient is so much larger than any other that, although its total coefficient is absolutely much larger than its direct, the proportional difference is not large.

Once again the direct coefficients agree fairly well in ranking, and the totals in their ranking at the extreme (Electricity, Petroleum Refining, Tourism), but a good deal of rearrangement occurs in the middle, and there are some serious differences in columns (4), (5) and (6) of Table III.7.b where there are marked disagreements over Services, Mining, Manufacturing, Construction Materials and Clothing. The position of agriculture is remarkably stable: according to these vectors of direct coefficients it is a relatively capital-expensive industry, and consideration of inter-industry requirements does not alter this conclusion.

9. The (arbitrary) method of separating imports on which Version II is based has already been described. The results are exhibited in Table III.8. The total coefficients are, of course, lower than those obtained in Version I, but, since industries differ substantially in their import requirements, the rankings of III.8.b differ markedly from those of III.7.b. The positions of Electricity, Agriculture, Transport Equipment, Construction, Tourism and Petroleum Refining are relatively unaffected (the extremes again), but the position

of some sectors, such as Metallurgy, is substantially altered. The import coefficients of III.8.c supply the explanation. The main lesson that should be drawn from comparison of Tables III.7 and III.8 is that imports are an important substitute for domestic capital as well as for current outputs.

The lessons that should be drawn from the whole analysis are for the most part obvious, but may be briefly summarized.

(i) Total capital requirements are in general very much larger than direct requirements alone.

(ii) Industries differ less in their total than in their direct requirements.

(iii) Since estimates of total requirements in general depend upon the direct requirements for every industry, errors in the estimation of direct requirements have widespread consequences.

(iv) In particular, the ranking of total coefficients is sensitive to apparently innocuous differences in direct coefficients that agree in ranking.

(v) Non-capital imports are important substitutes for domestic capital; and allowance for imports makes important changes to the picture of capital requirements.

10. It has already been remarked that the Input-Output Table used here is not to be relied upon, and that this analysis is intended largely for illustrative purposes. What it seems to illustrate is the importance of a good Input-Output

## TABLE III.8.a

### DIRECT AND TOTAL CAPITAL COEFFICIENTS
(Version II)

| Sectors | Total Coefficients | | | Ratios of Total to Direct Coefficients | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| 1. Tobacco | 1.86 | 1.83 | 1.32 | 14.3 | 7.4 | 7.6 |
| 2. Textiles | 2.22 | 2.22 | 1.61 | 6.4 | 3.3 | 3.5 |
| 3. Electricity and Gas | 6.10 | 5.04 | 5.97 | 1.3 | 1.2 | 1.2 |
| 4. Agriculture | 2.69 | 2.74 | 2.00 | 1.8 | 1.6 | 1.6 |
| 5. Chemicals | 1.79 | 1.84 | 1.29 | 3.8 | 2.0 | 2.0 |
| 6. Mining | 2.14 | 1.78 | 1.55 | 2.4 | 1.7 | 1.5 |
| 7. Manufacturing | 1.36 | 1.60 | 1.12 | 3.1 | 1.9 | 1.9 |
| 8. Metallurgy | 1.35 | 1.43 | .99 | 4.5 | 2.4 | 2.4 |
| 9. Services | 3.81 | 2.25 | 1.55 | 1.1 | 1.1 | 1.1 |
| 10. Petroleum Refining | .31 | .59 | .41 | 1.0 | 1.0 | 1.0 |
| 11. Clothing | 2.27 | 1.76 | 1.33 | 13.4 | 10.4 | 7.9 |
| 12. Construction Materials | 1.94 | 1.68 | 1.52 | 3.0 | 2.6 | 2.4 |
| 13. Transport Equipment | 1.13 | 1.00 | .83 | 4.3 | 3.8 | 3.1 |
| 14. Construction | 1.32 | 1.08 | .85 | 9.4 | 7.7 | 6.1 |
| 15. Tourism | .90 | .91 | .81 | 1.6 | 1.7 | 1.5 |

Table, which is obvious, and of really accurate estimates of direct capital requirements, which was perhaps not so obvious: this appears to be a case in which «near enough» is *not* good enough. This

TABLE III.8.b

SECTOR RANKING OF TOTAL CAPITAL COEFFICIENTS[1]

| | Sectors | Ranking of Total Capital Coefficients | | |
|---|---|---|---|---|
| | | (1) | (2) | (3) |
| 1. | Tobacco | 8 | 6 | 8 |
| 2. | Textiles | 5 | 4 | 3 |
| 3. | Electricity and Gas | 1 | 1 | 1 |
| 4. | Agriculture | 3 | 2 | 2 |
| 5. | Chemicals | 9 | 5 | 9 |
| 6. | Mining | 6 | 7 | 5 |
| 7. | Manufacturing | 10 | 10 | 10 |
| 8. | Metallurgy | 11 | 11 | 11 |
| 9. | Services | 2 | 3 | 4 |
| 10. | Petroleum Refining | 15 | 15 | 15 |
| 11. | Clothing | 4 | 8 | 9 |
| 12. | Construction Materials | 7 | 9 | 6 |
| 13. | Transport Equipment | 13 | 13 | 13 |
| 14. | Construction | 12 | 12 | 12 |
| 15. | Tourism | 14 | 14 | 14 |

1. Ranked before rounding off coefficients.

being so, it may be worth devoting a little more attention to the measurement of capital coefficients.

The manner in which the incremental ratios used here were generated was discussed in III.7

above. The object of the moving-average technique is to smooth out cycles in capacity utilisation. The fact is, however, that incremental ratios obtained in this way are very dependent upon the

TABLE III.8.c

DIRECT AND TOTAL IMPORT COEFFICIENTS

| | Sectors | Direct Coefficients (1) | Total Coefficients (2) | Ratios of Total to Direct Coefficients (3) |
|---|---|---|---|---|
| 1. | Tobacco | .04 | .09 | 2.2 |
| 2. | Textiles | .06 | .12 | 1.9 |
| 3. | Electricity and Gas | .05 | .11 | 2.4 |
| 4. | Agriculture | .04 | .07 | 1.8 |
| 5. | Chemicals | .08 | .12 | 1.6 |
| 6. | Mining | .04 | .07 | 1.6 |
| 7. | Manufacturing | .15 | .25 | 1.7 |
| 8. | Metallurgy | .24 | .38 | 1.6 |
| 9. | Services | .02 | .04 | 1.6 |
| 10. | Petroleum Refining | .67 | .68 | 1.0 |
| 11. | Clothing | .07 | .13 | 1.8 |
| 12. | Construction Materials | .07 | .15 | 2.1 |
| 13. | Transport Equipment | .13 | .23 | 1.8 |
| 14. | Construction | .10 | .17 | 1.8 |
| 15. | Tourism | .03 | .04 | 1.5 |

rate of change of the labour force as well as upon the rates of change of capital and output. With a constant labour force, we should observe diminishing returns to capital, and therefore incremental ratios that exceed average ratios and rise over time. With an increasing labour force, observed incremental ratios depend on the extent to which diminishing returns are being offset by the increase in labour, i.e., they depend on the actual change in capital intensity. This may be clarified by consideration of a Cobb-Douglas production function. Suppose that we have

$$X = A L^{a} K^{1-a}$$

then

$$dX = a \frac{X}{L} dL + (1-a) \frac{X}{K} dK$$

(since the marginal products are equal to the weights multiplied by the average products). If there were no change in the labour force, this would give

$$\frac{dK}{dX} = \frac{1}{1-a} \frac{K}{X}$$

Using our weight for manufacturing [1] of 0.72, this gives an incremental ratio approximately 1.4 times the average ratio. Coutsoumaris ([ 8 ], pp. 158 - 161) gives average ratios obtained from balance sheet data and incremental ratios obtained by the moving-average technique. His incremental ratio (Value Added) of 1.83 and average ratio (Value Added) of 1.0 for total manufacturing thus agree moderately; but the average ratio of 1.0 is to *depreciated* capital.

1. See Archibald, *Investment and Technical Change in Greek Manufacturing*, section II.

In fact, of course, the labour force has been changing, and we may see how this will affect the measurement. Let

$$\frac{dL}{dK} = h \frac{L}{K}$$

Then

$$\frac{dX}{dK} = a\,h \frac{X}{K} + (1\text{–}a) \frac{X}{K}$$

or

$$\frac{dK}{dX} = \frac{1}{s} \frac{X}{K}$$

where $s = a(h\text{–}1) + 1$. We may use the numbers obtained in the study of Technical Change in Manufacturing[1] to make a rough evaluation of s for manufacturing. Notice that $h = \frac{dL}{L} \Big/ \frac{dK}{K}$. For the period 1951 - 61, $\dot{L} / L$ was estimated at 0.94 % p.a., and $\dot{K} / K$ at 4.3% (depreciated) or 9.1% (gross, adjusted). This gives two possible estimates for s, if we continue to take a as 0.72 : s = 0.44 (depreciated) or s = 0.35 (gross, adjusted). The result is that the incremental capital coefficient should be about twice the average (depreciated) coefficient, or three times the average (gross) coefficient. We do not seem to observe such a relationship in the available measures.

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1. Ibid.

One reason is doubtless technical change. Even when $\dot{K}/K$ was adjusted to approximately 9.1% p.a., residual r, or disembodied technical change, was still some 3.9% p.a. in manufacturing. If we took this at face value, it would mean that an increase of nearly four per cent per annum in manufacturing output could be obtained without investment. I should not myself care to interpret it in this way. What we may notice, however, is that measured capital coefficients will be greatly affected by this phenomenon. If the production function is approximately described by $X = Ae^{rt}L^{a}K^{1-a}$, then incremental capital requirements are not given by constant ratios but are functions of the *proportional* change in output required. Similarly, the moving average technique of measuring incremental coefficients fails in its purpose. As already noted, it is intended to smooth out short-term fluctuations in capacity utilisation; but in fact it will also «smooth out» differences in incremental capital requirements *caused* by differences in the historical growth rate. Our r is a residual: for given inputs and weights, it depends directly on the actual rate of growth of output. The higher this is, the higher r is, and so much the lower is an incremental capital coefficient obtained by assuming constancy and averaging. Thus measured incremental coefficients must be negatively associated with the actual rate of growth of output in the time/industry chosen for measurement. Extrapolation of such coefficients into a future of different rates of growth of output (not to mention different rates of change of capital intensity) then becomes a very doubtful operation indeed. It does seem, however, that, with some attention to the production function and the observed and desired rates of change of output and labour, it should be possible to improve upon the rude averages that we have now.[1]

1. For some other methods of measurement, and discussion of the relationship between the average and marginal ratios, see Cameron [3].

## IV. CONCLUSION

It is not necessary to provide a summary of such a brief and sketchy treatment as has been offered here, but one final point may be made: *not all costs are in the Input-Output Table.* This is only to repeat what is well known, that social costs may exceed private costs (and not even all private costs may be in the Input-Output Table). In some instances, this is already allowed for in discussion: some people do not like to have tourists around (there are apparently external diseconomies associated with an increase in employment in catering). It is therefore possibly worth remarking on the social costs of industrialisation. I do not mean to enlarge upon the familiar evils of air pollution (although I may remark that smog is like obesity: people who suffer from neither take neither seriously, and people who suffer from either find a cure infernally troublesome). What I am concerned with is that industrialisation requires a programme of public expenditure which must be added to the total private capital requirements before a fair assessment can be made. That this is so is well known in general qualitative terms, just as it is well known that there are inter-industry capital requirements, but in neither case is it easy to get numbers.

The social capital required for major industrialisation can probably be allocated to two major requirements: training and relocating the labour force. Increased expenditure on education may well be judged a good thing in its own right, and worth while anyhow, but in so far as it is necessary to build vocational schools, whether in electrical engineering or veterinary surgery, their costs should be added to the total requirements of the appropriate industry. Industrialisation, however, involves specific relocation, with a bill for housing, roads, sanitation, and so on. (Notice that housing may be an important item of *private* cost that does not appear in the Input-Output Table.) I have no numbers to offer here, only a plea that some estimates be made, and the cost of major industrialisation fairly assessed, before Greece is irrevocably committed to a programme which may not survive the Common Market.

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