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A Medium Term Planning Model For Ireland

by

DAVID SIMPSON

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A Medium Term Planning Model For Ireland

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ABBREVIATIONS

I-O	Input-Output
ISB	Irish Statistical Bulletin
NA 65	National Income and Expenditure, 1965 edition
CIP	Census of Industrial Production
NNP	Net National Product
SA	Statistical Abstract of Ireland
CPI	Consumer Price Index
UNYNAS	United Nations Yearbook of National Accounts Statistics
CSO	Central Statistics Office
NIEC	National Industrial Economic Council

Foreword

The purpose of economic planning models is to show which choices are available in a particular situation. In the short run, this can be done by predicting what is likely to happen if policy is not changed. In the longer run, there is not a great deal of point in trying to predict what will happen if no changes are made, since changes are certain to come. This makes it all the more important to show what choices are open and what the consequences of each would be. This is what Dr. Simpson has done in his medium term planning model for the Irish economy. He suggests that there has been a tendency for economic planners in many countries to pay attention too exclusively to avoiding strains and bottlenecks in the economy—that is, simply to ensuring that developments in different parts of the economy are consistent with each other—and not enough to securing the most efficient distribution of resources between different sectors of the economy. This model illustrates the improvements in productivity and income which might be possible in Ireland if, over a period, efforts were made to redistribute labour and capital between different parts of the economy in the most efficient way possible.

Dr. Simpson's model is designed to show what distribution of labour and capital between different sectors would maximise household consumption, taking account of exports and imports—the balance of payments and the relation of internal to external prices, the changing size of the population, the supply of skilled and other labour, and the supply of capital from at home and abroad.

Since the model is designed to produce a range of projections about some future year, given information about an earlier year, it was decided to test it by making a projection of the year 1964 using 1956 as the base year. The results showed that the model can produce a range of alternative programmes for the Irish economy in a given year which are detailed, consistent, efficient and above all, sensible. Once the basic data have been prepared, such a projection can be produced by the computer within four weeks at a cost of less than £100.

As a result of applying the model to the 1956-1964 period, it is possible to infer what would have been the most efficient allocation of resources in the Irish economy during that period. Among the results of the model are the following:

(*a*) a greater share of the nation's scarce resources should have been devoted to the sectors Agriculture, Livestock Products, Drink and Tobacco. Increases in the exports and output of these sectors would take place at the expense of Construction, Electricity, Gas and Water, Transport and Trade, and Services.

(*b*) With the supplies of labour and capital actually available and the same balance of payments deficit, levels of national income and consumption about 10% higher than the actual could have been realised by the more efficient allocation of these resources. This would have meant adding rather more than £100 to the income of every household in Ireland in 1964.

(*c*) The supply of skilled labour provides the greatest limitation on increases in output in the Irish economy. The shadow prices calculated by the model suggest that the actual average wage of skilled labour is too low, and that of unskilled labour is too high.

It cannot be emphasised too strongly that these conclusions should not be applied to the real world without first appreciating certain limitations of the model which may have an influence upon its results. Two assumptions are particularly important: that export demand for the output of each sector is perfectly price elastic, and that employment is proportional to output in each sector (except agriculture).

Additional information is all that is required to modify these assumptions: they are not a necessary characteristic of the model. Meanwhile, it is probably safe to conclude from the results that increases in the output of the traditional industries (Agriculture, Livestock Products, Drink and Tobacco) can be achieved at little cost to the rest of the economy. In other words, it may be possible to develop the newer manufacturing industries *and* the traditional ones at the same time. Another practical implication of the model is that some attention should be given to increasing the supply of skilled labour, through labour-training activities, incomes policy, or by tapping the reservoir which appears to exist in the services sector.

The model is a linear programming model consisting of about one hundred and twenty equations and a slightly larger number of variables. The objective function is household consumption in the terminal year, and the principal constraints relate to labour, capital and the balance of payments.

A MEDIUM TERM PLANNING MODEL FOR IRELAND

by

DAVID SIMPSON*

1. INTRODUCTION†

Programmes of economic development involve choices amongst alternative economic policies. Amongst the different development policies which have been adopted at various periods in Ireland are:

(*a*) industrial import substitution, (i.e. the substitution of domestic production for imported industrial goods). This was a feature of the period from 1922 until the Second World War, and then again in the late forties and early fifties.

(*b*) negative industrial import substitution. This is almost certain to follow the Anglo-Irish Free Trade Agreement which came into effect in July 1966.

(*c*) industrial export promotion. This is a policy which has been in effect since the middle fifties.

(*d*) agricultural import substitution. The substitution of domestic production for imports of agricultural goods was a feature of the period of the War, and might conceivably recur following Irish membership of the EEC.

Yet, for a number of reasons,[1] the general practice of countries undertaking formal development programmes has been to pay less attention in their planning procedures to questions of choice, (*cr* productivity *or* efficiency) and more to questions of balance, (*or* consistency). Development plans tend to emphasise the balance between requirements and availabilities of resources and materials, rather than the allocation of these resources between more productive and less productive uses.

The capital-output ratio, for example, is a device which is widely used to calculate the capital requirements associated with a planned level of output. But the actual value of the ratio depends on the uses to which the capital is put: the more productive is the allocation of a given amount of capital, the lower is the value of the ratio. Since Irish capital-output ratios appear to compare unfavourably with those elsewhere, it may be inferred that the allocation of capital in the Irish economy is not particularly efficient.‡

The principal function of the model which is described in this paper is to compute efficient programmes of resource allocation. In other words, it shows which of all of the possible ways in which scarce resources can be distributed amongst the different sectors of the Irish economy will be the most productive. For any given set of values of the predetermined variables, the model calculates the level of output of each sector, the amount of employment, investment and imports consumed in each sector and the quantity of the output of each sector which is consumed by households and exported. In effect, the model selects the best development policy for any given set of circumstances.

[1](i) Balance problems are essentially short-run problems, and most countries have understandably been pre-occupied with short-run problems, so that they have given less attention to the longer-run issues of development policy.
(ii) While the problem of choice is particularly important in small countries, like Ireland, which cannot expect to produce the whole range of primary products and manufactures, planning techniques have been developed in large, self-sufficient countries.
(iii) It is much easier to devise planning techniques to ensure consistency than it is to ensure efficiency.

*David Simpson was a Research Officer with the Institute. The paper has been accepted for publication by the Institute. The author is responsible for the contents of the paper including the views expressed therein.

†The author would like to thank Dr. R. C. Geary for his valuable criticisms.

‡ United Nations Economic Commission for Europe, *Some Factors in Economic Growth in Europe During the* 1950's; Geneva, 1964, chapters II and III.

The present model follows the usual practice in linear programming models of maximising a function subject to a number of restrictions. In this case, total consumption is maximised subject to restrictions which reflect the availability of labour, capital, and foreign exchange, as well as the intersectoral relations of the economy. An account of the relationships which constitute the model is given in Chapter 2.

Since one of the practical uses of the model might be in forecasting or planning over a 5–10 year period, it was decided to make a projection of the year 1964 using 1956 as the base year. It must be emphasised that the model solution does not represent a pure forecast of what the actual pattern of output, etc., would be in 1964, but rather what the most efficient pattern would have been in that year. As explained in the text, the choice of the years 1956 and 1964 was determined by data availability. The details of this simulated forecast, and an analysis of the results, are contained in Chapter 3.

Further tests of the model, which were undertaken to confirm the results of Chapter 3, are described in Chapter 4.

The model uses and generates a considerable volume of data. This data is drawn from different sources, and yet it must be consistent. A data framework or set of tables for handling the data is set out in Chapter 5.

Up to this point in the paper, all mathematical language has been deliberately avoided, in order to make the model and its operations intelligible to as many readers as possible. In describing a mathematical model, however, mathematics cannot be avoided altogether, but only postponed. Chapter 6 contains a complete algebraic formulation of the model.

The sources of the data which were used in the tests of the model for the years 1964 and 1956, and the methods of estimation of the predetermined variables, are described in Chapters 7 and 8. Since it is only necessary to read these Chapters to think of improved methods of estimation, it may be worth emphasising the distinction between the model itself, and the data which have been used in the tests.

Although the model provides exact quantitative solutions, such precision is achieved—as in all models—at the price of oversimplification. It must be realised therefore, that every solution is open to a number of interpretations, and its application to the "real world" is not automatic but calls for a considerable degree of judgement.

The results of the tests reported in Chapters 3 and 4 show that this model can produce a wide range of alternative programmes for the Irish economy whch are detailed, consistent, efficient, and, above all, sensible.

Once the basic data has been prepared and allowing for errors in card-punching and programming, experience shows that a range of alternative forecasts for a future year can be produced by the computer within four weeks at a cost of less than £100.

The tests of the model have produced some interesting inferences about the allocation of resources in the Irish economy in the period from 1956 to 1964. These are discussed in Chapter 9.

2. THE MODEL

This chapter describes a model which has been developed for medium-term analysis of the structure of the Irish economy. Among its practical uses is in planning or forecasting for a period of 5–10 years. Although it may be regarded as an extension of Geary's model,[1] it is really a variant of a model formulated by Bruno[2] for the Israeli economy, which in turn owes its origin to the work of Sandee,[3] Chenery,[4] and others.

It is a general equilibrium model which is designed to represent the principal structural features of the contemporary Irish economy, i.e. the sectoral composition of consumption, foreign trade, investment and employment. It is also a normative rather than a positive model. In a positive model, a single solution, (typically, the values of output of each of the sectors of production), is determined by a given set of values for the predetermined variables, (typically, final demand). But in a normative model, a number of alternative solutions are consistent with the given set of values. What the model does is to select that one out of all of the possible distributions of output which gives the greatest value of consumption or national income or whatever else one chooses to maximise.*

[1]R. C. Geary, "Towards an Input-Output Decision Model for Ireland", *Proceedings of the Statistical and Social Inquiry Society of Ireland*, XXI, 2, 1965.

[2]M. Bruno, "A Programming Model for Israel", in I. Adelman and E. Thorbecke (eds.), *The Theory and Design of Economic Development*, The John Hopkins Press 1966, also M. Bruno "Optimal Patterns of Trade and Development", (Mimeographed), Bank of Israel, Jerusalem, 1966.

[3]J. Sandee, *A Demonstration Planning Model for India*, Asia Publishing House, New York, 1960.

[4]H. Chenery, "Comparative Advantage and Development Policy", *American Economic Review*, March 1961.

*The present model can easily be converted to a positive input-output model.

When the model is being used for forecasting or planning, then the principal *endogenous* variables, (i.e. those variables for which a solution is to be found), are the levels of output, and of consumption, investment, exports, imports and employment in each sector, and the prices of the primary inputs. The principal *exogenous* variables, (i.e. those whose values are assumed to be known), include the total population and the level of government expenditure, and changes in stocks, as well as the total supplies of the three primary inputs, labour, skilled labour, and foreign exchange. Among the principal parameters of the model are the elasticities of household consumption, and the input coefficients of imports, capital, and labour into each sector, as well as interindustry coefficients of the Leontief type.

Solutions are obtained by maximising total household consumption in the last year of the forecast period, subject to the constraints represented by the relations of the model. In the tests with the model which are described below the year 1956 was used as the base-year from which a projection of the year 1964, as the end year, was made. In another trial, using different parameters and exogenous variables, the year 1956 was used both as base-year and end-year. An important feature of the model is that the value of one or more of the parameters or exogenous variables can be allowed to vary continuously so that we can trace out alternative solutions and thus establish relations among particular variables.

A perfectly general algebraic formulation of the model is given in Chapter 6. The components of the model are described in the following paragraphs: the numbers in brackets refer to the equations of Chapter 6.

For any given set of values for the predetermined variables, the model will produce an optimal solution. It is known as an optimal solution because it is that solution which is associated with the maximum value of the function which is to be maximised, (i.e. *the objective function*, which, in the case of the present model is equation (0). This equation simply defines total household consumption as the sum of the consumption goods supplied by each sector. The model produces an optimal solution by finding that solution which maximises the total value of consumption, and at the same time satisfies the constraints expressed in equations (1) to (18).

In general, all money variables are measured in the prices of the base year, with the exception of F in equation (16), which is measured in units of foreign exchange in end-year prices (i.e. in pounds sterling).

In the tests of the model described below, sixteen sectors of production are distinguished. The 16-sector classification, (see Appendix I) is an aggregation of the 36 sectors of the 1956 Table based upon the criterion of similarity of the proportions of inputs imported and of output exported. The sectors Transport and Trade were aggregated because together they form the margin between producer's and purchaser's prices. Needless to say, it would have been preferable to use the 36-order classification, and to have broken down further some sectors—notably agriculture—but this would have increased prohibitively the amount of work.

(*a*) Output Determination

The sixteen equations (1) represent the disposal of the current output of each of the sectors of production among interindustry, households, exports and other uses. The total supply of sector i comes not only from domestic productions but also from competing imports, $(-S_i)$. As described in section (*d*) below, the level of S_i is determined partly by the model, and partly exogenously. This is true also, of I_i, the capital goods produced by sector i. All the other elements in (1), except G_i, government purchases of the output of sector i, are determined by the model.

The interindustry coefficients a_{ij} are normally derived from a base year table, and therefore require to be projected for use in a model which refers to the end-year of a forecast period. In Irish circumstances of an open economy with a small but rapidly growing industrial sector adapting towards freer trade conditions it seems likely that changes in the interindustry coefficients will be greater than in a more industrialised and more closed economy. On the other hand, in such an economy the interindustry coefficients play a less important role in determining levels of output. Methods of projecting coefficients can range from the selective updating of a few major coefficients to a comprehensive revision of the whole matrix. In the trial "forecast" of 1964, some of the 1956 coefficients, particularly the rows Noncompeting Imports and Electricity, Gas, and Water were revised in the manner described in Chapter 7.

(b) Household Consumption

The sixteen equations (2) state that consumption of the output of sector i is determined by consumption at some reference point, the consumption expenditure elasticity, and the total level of total consumption. The reference point can either be estimated by successive approximations, as in an actual forecast, or from information about the actual structure of consumption, as in our tests. In order to introduce some flexibility[1] into the model, we replace each such equation in the actual computations with two equations,

[1]See Chapter 6.

$$C_i \geqslant 0{\cdot}90\ (\beta C - \alpha)$$

and

$$C_i \leqslant 1{\cdot}10\ (\beta C - \alpha)$$

What this means is that the consumption pattern is able to vary and to adjust itself to relative factor scarcity within a 10% range on either side of the Engel curves. This permitted flexibility is to some extent a substitute for price elasticity.

Because of the importance of consumption, both in the aggregate and for most sectors, it is important to estimate the consumption expenditure elasticities, e_i, as accurately as possible. A comparative analysis of the forthcoming results of the Household Budget Inquiry 1966, with those for 1952 should be particularly helpful in deriving improved estimates of these parameters.

N, the level of population, is a parameter of key importance for Ireland and its explicit introduction makes it possible to calculate, within the framework of the model, the implications of its variation. However, in the tests described below, N did not vary.

The equation determining consumption of non-competing imports (3) is of the same form as the equations in (2), while (4) is simply definitional. Equation (5) is the aggregate savings relationship. It would be possible to select appropriate values for s and allow this equation to operate as an additional constraint upon the solution of the model. It is also possible to allow s to be determined, and then plot the range on the transformation curves corresponding to plausible values of s. This equation was not used in our tests of the model.

(c) Investment

There are five investment activities, denoted ${}_jI$. They are:

${}_1I$ Investment in Plant and Equipment
${}_2I$ Non Residential Building
${}_3I$ Investment in Housing
${}_4I$ All other Construction and Works
${}_5I$ Stock Change.

Each activity can be defined as a column showing the inputs from each sector of production and from non-competing imports. The row sum of the inputs from any sector i to each of the columns ${}_jI$ is equal to the total value of capital goods produced by sector i, i.e. I_i. Equations (6) and (7) state these equalities for all i and for m, and state further that the elements of the ^{jth} column are a given fraction, denoted by r_{ij} and r_{mj}, of the ^{jth} activity. Thus, it is assumed that the input structure of Non Residential Building does not vary with changes in the level of that activity.

In the tests with the model, the levels of the two activities Plant and Equipment Investment and Non Residential Building were to be determined, while the levels of the other three investment activities were fixed exogenously. Equation (8) is definitional.

The investment activities are connected to the levels of output of the sectors of production not only by the fact that they absorb part of the sectors output but also by the fact that the capital goods produced are, in turn, used in production. Equation (9) states that the level of investment activity j is determined by the levels of sector output times the ratio of investment of type j to output in each sector. In practice, only inputs of the two variable investment activities were considered in this way.

The foregoing treatment of investment has little to recommend it except simplicity.[1] One improvement depends on the availability of a matrix corresponding to the usual input-output table but showing the flows of *capital* goods from their sectors of origin to the sectors of use. This is unlikely to be forthcoming, but in any case it would provide only a marginal improvement. The fact is that there is no really satisfactory treatment of capital which is computationally manageable within the framework of a static intertemporal model. Dynamic multisectoral models on the other hand raise problems of their own, which have to be resolved before practical applications can be usefully attempted.

The procedure we have adopted, in effect, treats capital as an intermediate good and not as a primary input at all. Both Bruno and Sandee base their investment flow estimates upon capital stock coefficients plus the assumption that the investment in each sector in the end-year will be equal to 10% of the capital stock in that year. We did not have to make such an assumption since the investment flows in the years 1956 and 1964 were known.

(d) Imports

Imports are divided into two categories, competing and non-competing. Competing imports are those which are close substitutes for domestically produced goods. How imports are actually divided between these categories is purely a matter of definition. For certain types of analysis it is desirable to treat all imports as being competing. For the purposes of this model, it probably would have been easier to treat all imports as being noncompeting—which was the procedure adopted in constructing the 1960 (but not the 1956 or the 1964) input-output table. However, we wanted to see how import substitution, (positive or negative), works within the framework of the model, since this is a process which is likely to be an important feature of the Irish economy in the next ten years. Import substitution (positive) is the replacement of goods hitherto

[1]For an alternative treatment of investment, see Geary, *op. cit.*, pp. 23-25.

imported by domestic production, while negative import substitution is the process in reverse. In the version of the table which we used, both domestic output and competing imports were distributed along each row, the total value of competing imports being entered in a column with a negative sign so that the row total equals the value of domestic production. Noncompeting imports were entered as a single row, in the column of the industry to which they were inputs. The treatment of imports substitution is then as follows:

Competing imports in each sector i are written as $-S_i$. It is possible to place upper and lower bounds upon S_i with reasonable confidence. Ideally this should be based upon special knowledge of the situation in the industry concerned. In practice, it is sufficient to take a range of 20% on either side of the existing level, S_i, to test the process. Thus we have equations (11).

Now, if competing imports are completely replaced by domestic production in sector i, or *vice versa*, then S_i will change its sign. (Since import substitutes are written as competing imports, but with an opposite sign.) However, it is impossible to obtain a feasible solution to a linear programming problem if a variable is permitted to take on negative values. Consequently, the following transformation is necessary:

Let

$$S_i = R_i + \underline{S}_i$$

where

$$0 \leqslant R_i \leqslant (\bar{S}_i - \underline{S}_i)$$

In this way, while the variable R_i takes on only non-negative values it is possible for S_i to change signs. The model determines the value of R_i while S_i is of course predetermined. If the result is such that

$$R_i + \underline{S}_i > S_i$$

then (positive) import substitution has occurred. Conversely if

$$R_i + \underline{S}_i < S_i$$

then negative import substitution has taken place.[2]

The total value of competing imports in each sector—determined partly by the model—enters into equation (10) which shows each element in the overall demand for imports. The parameters d_i are supposed to measure the ratio of the c.i.f. value of the competing import to the domestic cost of production. In a wider application of the model it would be desirable to empirically estimate, however roughly, at least some of the d_i. In the trials all the d_i were set equal to unity. The noncompeting import coefficients, m_j, are particularly important in the model, since they constrain the aggregate level of output to the supply of foreign exchange available to finance imports. They are, however, difficult to predict empirically and depend upon the existence of an input-output table to be measured *ex post*.

[2]In the tests of the model, import substitution possibilities were permitted in three sectors, Drink, Textiles, and Vehicles. In all other sectors, R_i was set at zero. Ordinarily, S_i is negative, i.e. competing imports are written with a negative sign.

(e) Exports

Exports are divided into two categories. Expenditure on travel and tourism by non-residents are treated as a separate activity, T, whose level may vary between upper and lower bounds. Tourist expenditure on the output of any sector i is proportional to total T. All other exports of goods and non-factor services are constrained between upper and lower bounds, which differ for each sector i. In forecasting, one would probably take the level of exports of the base-year as the lower bound, and let the upper bound be determined by discussions with informed opinion inside or outside the industry. In the trials of the model, the bounds were fixed 20% on either side of the actual value of the exports for 1956 and of the estimate for 1964.

The method of allowing exports to vary within bounds is appropriate in many cases where it is easier to forecast a range for exports, and the bounds can represent constraints on either supply or demand or both.

While it is possible to project trends in the quantities of industrial goods exported, and to forsee a reasonable stability in their prices, both prices and quantities of cattle exports fluctuate from year to year. If a systematic relationship is found to exist between price and quantity, such as a supply or demand function, this can be approximated by a step function within the framework of the model. It is also possible, where appropriate, to fix the value of exports of sector i or let it be proportional to total exports. Net factor income from abroad, V^E, is determined exogenously.

(f) Foreign Exchange

Foreign exchange is one of the three primary inputs in the model. Each term in equation (16) is expressed in pounds sterling in the prices of the end-year. This assumes that one can forecast price indexes for each category of exports and for imports as a whole. It would also be necessary to forecast a range of values for the foreign capital inflow, F, since this is one of the principal parameters to be varied. One could extend the model by including the increasing cost of borrowing as F increases but this is omitted from the present formulation.

(g) Labour

There are two equations, (17), one for total labour inputs and the other for "skilled" labour, each of which state that the sum of the numbers engaged in each sector of the economy should not exceed the total supply of labour of that type. Although both are formally constraints, it would be surprising if total labour were an effective constraint on output in the Irish context. Estimates of what constitutes "skilled" labour and how many skilled workers are actually engaged in each sector are at present quite uncertain. However, if and when a breakdown of sectoral employment by different skills becomes available, this would improve considerably the usefulness of the model. It would be worthwhile then to add a labour training activity which would have as its inputs capital and unskilled labour, and as its output skilled labour. At present it is necessary for anyone using the model for forecasting purposes to make their own projections of changes in the productivity of both "skilled" and of total labour. These labour coefficients are parameters which can usefully be varied, as can the total supplies of both types of labour.

(h) GNP Determination

(18) is not a restriction but merely a definitional equation. It is worth stressing that the variables are expressed in the prices of the base-year.

3. TESTS OF THE MODEL: THE 1964 PROJECTION

Introduction

It was stated in Chapter 2 that the model provides the maximum value of total household consumption consistent with any given set of values of the exogenous variables. At the same time it shows the sectoral distribution of exports, and outputs, and imports and employment associated with this maximum value. Thus, each solution to the model can be said to represent an efficient allocation of the resources of the economy. It also represents an allocation which is internally consistent, because the supply of and demand for resources and for goods and services is balanced for each sector as well as in the aggregate. While all multi-sectoral models produce solutions which are internally consistent, only models which involve optimisation produce solutions which are *both* consistent *and* efficient.

In this chapter, we present the results of an experiment in which the model simulates a projection of the year 1964 using 1956 as the base-year. Such an experiment cannot, of course, provide a conclusive test of the model. Differences between model solutions and the corresponding actual 1964 values can arise from two different sources

(i) deficiencies in the data,
and (ii) defects in the structure of the model
apart from
(iii) deviation of the actual allocation of resources in 1964 from the optimal.

Deficiencies in the data arose in the present experiment, as they would in a real forecast situation, because we had to estimate (by projecting 1956 data) end-year values of some of the principal parameters of the model, viz. the consumption elasticities, the interindustry and the import coefficients. This source of error can be eliminated for the purpose of testing the model (although never in an actual forecast) by using known values of the parameters. Accordingly, Chapter 4 describes the results of a second experiment in which 1956 acted as both base-year and end-year for the model.

The choice of the base-year and end-year for the projection described in this chapter was determined by the availability of data. Since import substitution is likely to be an important feature of the Irish economy during the next ten years it seems desirable that the model should be able to simulate this process. To do this, an input-output table must be available in which competing imports are distinguished according to the corresponding sector of production. So far, 1956 is the only year for which such a table is available. 1964 was chosen as the end-year, because it was the latest year for which the annual data required by the model was available when the experiments began.

A single optimal solution is associated with a given set of values of the predetermined variables. If we allow the value of one of the exogenous variables or one of the parameters to vary, we shall of course, obtain a series of optimal solutions. This is useful for two reasons. First, it may be easier to specify a range of values for a particular predetermined variable (e.g. the net capital inflow in 1970) rather than a single value. Secondly, it enables us to determine the relationship between some of the more important variables in the model. These relationships and the pattern of solutions will turn out to be as interesting as any individual solution by itself. In the experiment described below F, the net capital inflow, which is equal in value but opposite in sign to the current account deficit in the balance of payments, was allowed to vary over a wide range of values, all the other predetermined variables being

held constant. The procedure was repeated using a different value for L_1, the total supply of skilled labour.

TABLE 3.1: RATES OF GROWTH OF PRINCIPAL AGGREGATES, 1956–1964

(Compound Average Annual Percentage Rates of Growth)

		Consumption	Employment	Exports	Imports	GNP
		(1)	(2)	(3)	(4)	(5)
Actual		2·9	−1·2	6·8	7·9	2·9
Model	A.	3·5	−1·9	7·2	8·2	3·5
	B.	4·3	−0·9	7·7	8·7	4·3

Sources: Actual, Chapters 7 and 8.
Model, Appendix Tables 1 and 2
A: F=31·5, L_1=236·9
B: F=31·5, L_1=256·9

Table 3.1 shows the actual growth rates of the principal endogenous variables between 1956 and 1964, together with two model solutions for values of F at 31·5, (the actual value of F in 1964). Solution A represents the situation where the supply of skilled labour is fixed at the actual level for 1964, while solution B is the result when the skilled labour force (but not the total labour force) is assumed to have been larger by twenty thousand (about 8%). Thus, the difference between solutions A and B can be interpreted as the benefits which might have been obtained from increased labour training.

The implications of Table 3.1 are clear: with the resources available to the Irish economy in the period from 1956 to 1964, faster rates of growth of Consumption, GNP, Exports and Imports could have been obtained if these resources had been distributed differently, (i.e. more efficiently), between sectors.[1]

The difference between the actual proportional distribution of output among sectors in 1964 and the optimal proportional distributions corresponding to the model solutions A and B is shown in Table 3.2.

A comparison of model solution A with the actual percentage distribution in this table shows that the share of Agriculture, Livestock Products and Drink in the optimal distribution of output is greater than those sectors share of actual output in 1964. The share of Wood and Paper, Vehicles, Transport and Trade, and Services is less, while that of the other sectors is roughly the same as in the optimal as compared with the actual solution. When the supply of skilled labour is allowed to increase, (Solution B) permitting a higher level of output, the share of Textiles, Metals and Machinery, and Other Manufacturing is increased while that of Tobacco, Electricity, Gas and Water, Transport and Trade, and Services falls.[2]

TABLE 3.2: PERCENTAGE DISTRIBUTION OF OUTPUT BY SECTOR, 1964, MODEL AND ACTUAL

Sector	Actual	Model A	Model B
1. Agriculture	19·8	21·9	20·9
2. Livestock Products	9·1	10·1	9·4
3. Crop Products	6·5	6·2	6·1
4. Drink	3·1	3·3	3·1
5. Tobacco	2·6	2·6	2·3
6. Textiles	3·1	3·1	4·5
7. Apparel	4·5	4·6	4·8
8. Wood and Paper	3·8	3·5	3·6
9. Chemicals and Minerals	3·5	3·4	3·5
10. Metals and Machinery	4·5	4·3	5·1
11. Vehicles	2·7	2·4	2·7
12. Other Man. and Mining	3·6	3·7	4·1
13. Construction	8·0	7·8	7·4
14. Electricity, Gas and Water	3·3	3·1	3·0
15. Transport and Trade	12·6	11·5	11·4
16. Services	9·3	8·4	8·1
Total:	100·0	100·0	100·0

Source: Appendix Table 3.

TABLE 3.3: PERCENTAGE DISTRIBUTION OF HOUSEHOLD CONSUMPTION BY SECTOR, 1964, MODEL AND ACTUAL

Sector	Actual	Model A	Model B
1. Agriculture	15·3	16·8	16·2
2. Livestock Products	7·4	8·0	7·7
3. Crop Products	7·2	6·5	6·3
4. Drink	4·6	4·9	4·6
5. Tobacco	5·2	5·2	4·7
6. Textiles	1·8	1·9	2·0
7. Apparel	7·8	8·5	8·6
8. Wood and Paper	2·3	2·1	2·1
9. Chemicals and Minerals	2·4	2·3	2·4
10. Metals and Machinery	4·7	4·8	5·3
11. Vehicles	2·6	2·6	2·8
12. Other Man. and Mining	4·5	4·4	4·9
13. Construction	1·0	1·0	1·0
14. Electricity, Gas and Water	2·0	1·7	1·7
15. Transport and Trade	14·3	12·8	12·8
16. Services	11·6	10·6	10·5
Non Comp. Imports	5·4	5·8	6·2
Total:	100·0	100·0	100·0

The sectoral distribution of output which is generated by the model is largely determined by the composition of intermediate and final demand. Final demand consists of household consumption expenditure, exports, and other elements including investment and government expenditure. In these

[1]The model solutions for total employment depend upon the assumptions about the relationship between output and employment in agriculture. As described in chapter 7 it was decided to take the labour required per unit of output in Sector 1 to be only 75% of the ratio of numbers engaged to total agricultural output in 1964. In practice, one would expect a slower rate of decline of employment to be associated with faster rate of growth of national income and consumption.

[2]Similar sectoral distributions for capital investment, skilled and total labour force, and imports may be worked out by multiplying the sector output levels (shown in Appendix Table 3) by the corresponding sectoral coefficients (shown in Appendix Table 5.).

tests, government expenditure and part of investment expenditure is fixed, while the individual items of household expenditure are determined within limits by the level of total consumption expenditure and the elasticity of expenditure peculiar to that item.

Distribution of Consumption by Sector

Table 3.3 shows the percentage distribution of consumption by sector. For the model values of F and L_1 which correspond most closely to the actual situation in 1964, shown as solution A, it appears that the share of Agriculture, Livestock Products, Drink, Apparel, and Noncompeting Imports is greater than in the actual situation, whereas the share of Crop Products, Wood and Paper, Electricity, Gas and Water, Transport and Trade, and Services is less.

When the value of L_1 in the model is increased to 256·9, then the optimal pattern of consumption alters. The share of Metals and Machinery, Vehicles, Other Manufacturing and Imports in total consumption are increased, while there is a decline in Agriculture, Livestock Products, Crop Products and Tobacco, reflecting the consumption elasticities, which in turn are based on the actual changes in consumption over the period 1956–1964.

Exports and Comparative Advantage

If we examine solution A, it turns out that the total of exports of goods and non-factor services is quite similar to the actual value (at constant 1956 prices). However, the distribution of that total between the sixteen sectors of the economy and tourism is quite different, as Table 3.4 shows. This table shows that exports of Agriculture and Livestock Products, Drink and Other Manufacturing formed a smaller proportion of actual total exports in 1964, than the optimal pattern of exports would have suggested. Conversely, exports of Textiles, Apparel, Chemicals, Wood and Paper, Metals and Machinery, Transport and Trade, Services and Tourism, formed a larger proportion of actual exports, than they did in the optimal pattern.

But exports are free to vary within predetermined and fixed bounds, and the nature of the model is such that the exports of an individual sector is nearly always to be found at its upper or lower bound. Therefore, while it is interesting to see whether, in solution A, the exports of any sector is at its upper or lower bound, there is no significance to be attached to the *precise* value for a sector's exports in any single solution. What *is* significant is the *order* in which export activities move from their upper to their lower bounds as F is increased.

This order is determined by the ratio of the domestic factor cost incurred by a unit level of each export activity to the net foreign exchange earned per unit. The domestic costs of production include the direct and indirect content of both total and skilled labour while the net foreign exchange cost is the gross export revenue per unit *minus* the direct and indirect import content.

Thus, each sector of the economy can be ranked in an order which is determined by its export price and the relative factor intensity of the sector's output. Such a ranking provides a measure of comparative advantage as proposed by the Hekscher-Ohlin theorem. This theorem states that a country has a comparative advantage in those sectors whose output is relatively intensive in the factors with which it is abundantly endowed.

Where there are several scarce factors the ranking of sectors depends on the factor endowments. In the solutions which have been obtained from the tests of the present model, there have been effectively only two scarce factors, skilled labour and foreign exchange. In this case, the ranking is unaffected by allowing the supplies of skilled labour and of foreign exchange (the factor endowments) to be varied.

The comparative advantage ranking of Irish sectors is shown in Table 3.5; those with a relatively high ratio of domestic factor costs to net foreign exchange costs are at the top of the ranking.

Although this ratio could be computed directly for each activity, it is much easier to find the ranking by allowing F to vary. At very low values of F, all export activities are profitable. As F increases, one export activity after another, becomes, in turn, unprofitable. Thus, for values of F below 37·0 the net foreign exchange earned by exporting a unit output of the sector Apparel exceeds the domestic factor costs incurred. As F increases, the shadow price[1] of foreign exchange falls, and above F=37·0 it is no longer worthwhile exporting Apparel. The F values listed in Table 3.5 are those above which the corresponding activities become unprofitable.

The comparative advantage of each foreign trade activity depends, in general, upon all of the technical coefficients in the model, (labour, imports, inter-industry, etc.) as well as upon export prices and the relative supply of factors. In using the model for planning one would therefore incorporate expected changes in productivity, in export prices, and in factor supplies, just as most of the 1964 coefficients in the present test have been estimated by revising 1956 data. The resulting ranking does not then reflect simply *past* comparative advantage but *future* comparative advantage, so far as its elements can possibly be foreseen. In this way, a dynamic interpretation can be placed on the results of a formally static model.

[1]See p. 12 below for an explanation of this term.

Import Substitution

It is noticeable that import substitution activities have been included in the ranking of Table 3.5. Positive import substitution means the replacement of competitive imports by increasing domestic output, and is therefore an activity analogous to exporting since net foreign exchange is saved while domestic factor costs are incurred. Negative import substitution is the process in reverse. In this test of the model, the possibility of import substitution (positive or negative) was permitted in three sectors, Drink, Textiles and Vehicles. At very low values of F, positive import substitution took place in all three sectors up to the permitted limit. As F was increased, first Vehicles, then Textiles, and finally Drink swung to the opposite limit, where competing imports were replacing domestic production.

TABLE 3.4: DISTRIBUTION OF EXPORTS BY SECTOR, 1964

ACTUAL AND MODEL[1] 1964 AT 1956 PRICES

Sector	£ million		Per Cent	
	Actual	Model	Actual	Model
1. Agriculture	59·2	71·0	24·5	28·6
2. Livestock Products	50·3	60·4	20·8	24·4
3. Crop Products	4·7	3·8	1·9	1·5
4. Drink	6·0	7·2	2·5	2·9
5. Tobacco	0·1	0·2	*	0·1
6. Textiles	6·3	5·0	2·6	2·0
7. Apparel	9·6	7·7	4·0	3·1
8. Wood and Paper	4·9	3·9	2·0	1·6
9. Chemicals and Minerals	4·5	3·6	1·9	1·5
10. Metals and Machinery	14·4	11·5	6·0	4·6
11. Vehicles	2·0	2·4	0·8	1·0
12. Other Manufacturing and Mining	12·1	14·5	5·0	5·8
13. Construction	—	—	—	—
14. Electricity, Gas and Water	0·2	0·1	0·1	*
15. Transport and Trade	11·3	9·0	4·7	3·6
16. Services	9·8	7·8	4·1	3·1
Tourism	46·1	39·9	19·1	16·1
Total:	241·5	248·0	100·0	100·0

[1]=Model Solution A.
*=Less than 0·05.

It may be asked why each import substitution activity does not appear in the same position in the comparative advantage ranking as does the corresponding export activity. The explanation is that a unit of domestic output replacing imports saves an equal amount of foreign exchange while a unit of output exported earns that amount *times* the corresponding export price-index.

It should be emphasised that the model can be operated with import-substitution possibilities in all sectors or in none: three were chosen merely as a trial.

Major Endogenous Variables

In the present experiment, F was allowed to increase continuously within the range between −50·0 and +100·0, and the model was programmed to generate a solution whenever an export activity left its upper bound. At each solution, C is maximised, and, as F increases, so does the maximum value of C, but at a diminishing rate. This is because, as F increases, resources such as skilled labour and foreign exchange can be released from exports industries and re-allocated to permit an increase in the total level of consumption. As the process continues, resources are released from relatively more productive export activities.

Diagram 1 shows three such transformation curves between F and optimal C levels. The curve 1964A shows the relation between F and C when the supply of skilled labour is fixed at its actual 1964 level, while 1964B shows the relation when the supply of skilled labour is increased. The origin of the curve 1956 is described in Chapter 4. All three curves are upward sloping, concave to the origin, and consist of linear segments of unequal length: each corner represents a change in the level of one of the foreign trade activities. And the slope of the curve at any point represents the marginal productivity or shadow price of foreign exchange at that point.

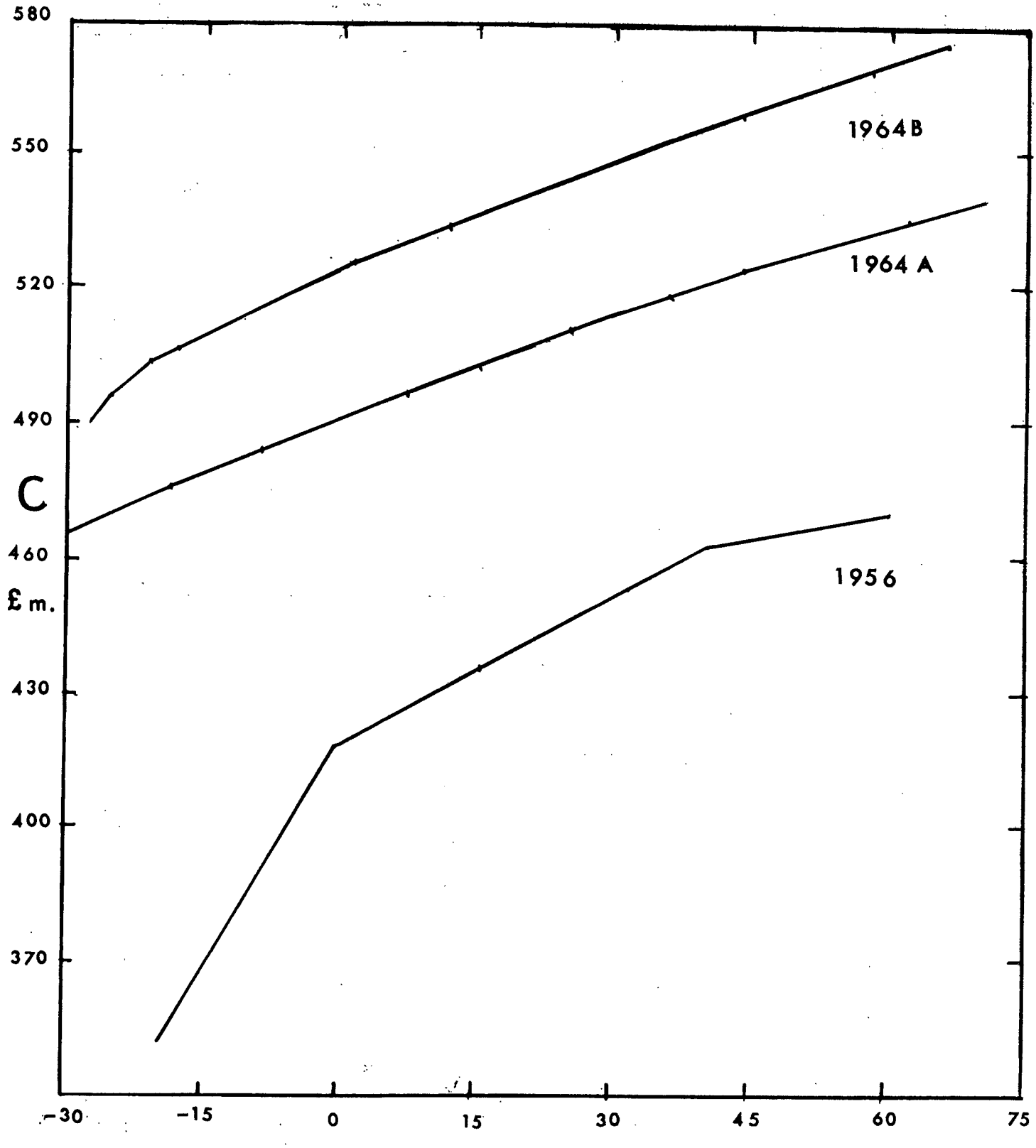
TABLE 3.5: COMPARATIVE ADVANTAGE IN THE IRISH ECONOMY, 1956–1964

RANKING OF FOREIGN TRADE ACTIVITIES BY RATIO OF DOMESTIC FACTOR COSTS TO NET FOREIGN EXCHANGE COSTS

	Activity	F
E_4	Drink	100·0
E_5	Tobacco	100·0
E_1	Agriculture, Forestry, Fishing	92·1
R_4	Drink	91·0
E_2	Livestock Products	66·6
E_{11}	Vehicles	65·7
E_{12}	Other Manufacturing+Mining	58·5
R_6	Textiles	46·7
E_6	Textiles	44·2
E_3	Crop Products	41·8
E_7	Apparel	37·0
E_T	Tourism	12·7
E_{15}	Transport and Trade	4·8
E_8	Wood, Paper and Printing	1·8
E_{16}	Services	−7·2
R_{11}	Vehicles	−11·6
E_{10}	Metals and Machinery	−18·0
E_9	Chemicals	−20·0
E_{14}	Electricity, Gas and Water	−20·2

1. Export Activities are denoted E_i, and Import Substitution Activities R_i,
Value of F based on Solution B.
The meaning of this table is explained in the text, pp. 8 and 9.

This diagram illustrates one of the functions of the model in generating a range of solutions which are feasible and efficient. Thus, it defines the area of choice for policy purposes. This area can of course be further restricted by introducing additional constraints, either into the model, or directly into the


580
550
520
490
C
460
£ m.
430
400
370
1964B
1964 A
1956
-30
-15
0
15
30
45
60
75
F Millions

transformation curve itself.[3] For example, portions of the curve corresponding to extremely high values of F might be ruled out on grounds of the unacceptability of so large a balance of payments deficit.

If one were to plot likewise the other endogenous aggregate variables,[4] one would discover that Total Exports, while remaining at its maximum value for very low levels of F, eventually decreases continuously as F increases. As this capital inflow increases it provides the foreign exchange not only to replace the amount earned by exports but to provide that required to finance the increasing imports of consumer goods. Increased consumption of domestically produced goods is provided for by output diverted from exports, so that eventually aggregate output after increasing at first, begins to fall. This is reflected in the movement of GNP, Total Employment, and Total Investment. In both Appendix Tables 1 and 2, GNP and Total Employment reach their maximum value together, followed by Total Investment. If the objective function were modified to include investment, an increase in F would lead to increased imports of capital goods.

[3]Theoretically, the best combination of C and F could be determined by applying to the appropriate transformation curve in Diagram 1, a social welfare function specified in the form of a set of indifference curves, upward sloping and convex to the origin. The parameters of this function would reflect the costs of additional foreign borrowing and any other relevant relation between C and F. The *optimum optimorum* would then be determined at the point of tangency of the transformation curve with the highest indifference curve.

[4]See Appendix Tables 1 and 2.

TABLE 3.6: DISTRIBUTION OF TOTAL LABOUR FORCE BY SECTOR, MODEL AND ACTUAL 1964

Sector	(Thousands of Man Years)		
		Model	
	Actual (1)	A (2)	B (3)
1. Agriculture	352·0	307·2	319·3
2. Livestock Products	12·1	14·1	14·3
3. Crop Products	16·6	26·7	28·6
4. Drink	8·8	9·9	10·1
5. Tobacco	2·2	2·3	2·2
6. Textiles	16·7	17·6	28·3
7. Apparel	35·8	38·2	43·7
8. Wood and Paper	25·3	24·8	27·6
9. Chemicals and Minerals	16·6	17·2	19·2
10. Metals and Machinery	25·8	25·8	32·9
11. Vehicles	11·0	10·4	12·4
12. Other Manufacturing and Mining	21·1	23·1	27·7
13. Construction	72·0	73·7	76·4
14. Electricity, Gas and Water	11·0	10·9	11·8
15. Transport and Trade	182·3	174·7	188·3
16. Services	158·8	151·1	159·3
Sub-Total, Sectors 1–16:	978·1	927·5	1,002·2
Unemployed (Actual and "disguised")	58·0	108·6	33·9
Total Labour Force	1,036·1	1,036·1	1,036·1

Note: The number of "disguised" unemployed appear in Sector 1 in column (1), but in the Unemployed row in columns (2) and (3).

Employment

Employment is one of the critical variables in economic growth in Ireland, not because, as in so many other European countries, the total supply of labour is likely to be an effective constraint upon the aggregate level of output,[1] but because an increase in the numbers at work is one of the targets of policy.

Table 3.6 shows the distribution of the labour force among the sixteen sectors of the economy in 1964, together with two comparable model solutions. The latter were obtained by multiplying the model outputs for each sector except Agriculture by the corresponding ratio of employment to output as actually observed in that year. This assumption of proportionality is not required by the model, but is due to the fact that estimates of the parameters of more sophisticated functions[2] are not available. In sector 1, Agriculture and Forestry and Fishing, it was assumed that that sector's output could have been produced by only 75% of the numbers actually at work in 1964. This accounts for the difference between the entries for sector (1) in columns (1) and (2) and in column (3) of the table. The balance of 88,000 workers was assumed to have been available for work in other sectors if required. This explains the figure of 108·6 thousand unemployed in solution A and the high levels of employment in all sectors other than sector 1 in solution B. Our assumption can be rationalised in terms of the existence of disguised unemployment in Irish agriculture: it was chosen not necessarily for its realism but for the scope which it permits the model.[3] The difference between the numbers at work in solution A and solution B is the result of allowing the available supply of *skilled* labour to be increased (e.g. through having trained more unskilled workers): the relaxation of this constraint permits an increase in the output of all sectors, but especially of sector 6, and therefore a corresponding increase in total employment.

A comparison of the actual distribution of employment among sectors 2–16 with model solution A shows that the optimal solution would imply a considerable reduction in the numbers engaged in Transport and Trade, Services, Electricity, Gas and Water, Vehicles, Wood and Paper, with an increase in all other sectors, but particularly in Apparel, Livestock Products, Textiles and Other Manufacturing and Construction. When the supply of

[1]While this statement may be true at the national level, it does not deny the possibility that in particular industries and areas unskilled labour may be scarce while the skilled labour supply exceeds the demand. See, for example, the results of the Drogheda manpower survey.

[2]How such parameters can be estimated is demonstrated by C. E. V. Leser in "Employment Functions for Industry Groups". ESRI. Memorandum Series No. 44.

[3]Had Agriculture been treated the same way as the other sectors of the model, the results would have shown increases in employment in Agriculture in proportion to increases in output.

skilled labour is increased, then the numbers engaged in Textiles and Apparel increase sharply. Since the labour coefficients are the same, the differences in the pattern of employment in the actual and the two model solutions arise purely from the difference in output.

TABLE 3.7: SHADOW PRICES OF PRIMARY INPUTS, 1964

	Skilled Labour		*Foreign Exchange*	
	Thousands of 1956 pounds per man year		Irish pounds per pound sterling	
L_1	236·9	256·9	236·9	256·9
F				
−28·0	1·6	0·4	0·9	2·1
−20·0	1·6	1·4	0·9	1·1
−8·0	1·7	1·6	0·8	0·9
—	1·7	1·6	0·8	0·9
15·0	1·7	1·7	0·8	0·9
31·5	1·7	1·7	0·8	0·8
45·0	1·9	1·7	0·6	0·8
60·0	1·9	1·8	0·6	0·6
75·0	2·1	1·9	0·4	0·6

Shadow Prices of Primary Inputs

The solutions which are described in this chapter were obtained from the model by maximising the total value of consumption, subject to constraints representing the availability of resources. We should have obtained exactly the same solutions, however, if we had formulated our problem in such a way as to minimise the total value of the available resources. The duality[1] of resource allocation and price determination in any model can be interpreted as the proposition that the optimum allocation of resources is an objective which is identical to the proper valuation of those resources. In determining the allocation of resources which will maximise consumption, the model simultaneously determines unit values or "shadow" prices for each resource in a way which amounts to an opportunity-cost valuation.[2] Thus, if all of resource i were fully used, and its supply could then be increased by one unit, without changing the optimal solution, then the maximum value of consumption would be increased by an amount W_i, where W_i is the shadow price of resource i. While, if some of the available supply of resource i remains unused in an optimal solution, then such a resource is a free good (e.g. $W_i=0$).

[1]The dual theorem is described by R. C. Geary and M. D. McCarthy in their *Elements of Linear Programming*, Griffin, London 1964, pp. 48–53, and Appendix C, and discussed more fully in R. Dorfman, P. Samuelson and R. Solow, *Linear Programming and Economic Analysis*, chapters 4 and 7.

[2]It is, in fact, a marginal productivity valuation. However, unlike the partial equilibrium analysis of neoclassical theory, in which factor substitution takes places within a single production activity, the model represents an application of general equilibrium analysis, in which factor substitution occurs as the result of varying combinations of activities in which factors are combined in fixed—but different—proportions.

Table 3·7 shows how the shadow price of two of the primary inputs, skilled labour and foreign exchange, change as the quantities available, L_1 and F, are allowed to vary. As the supply of one input increases it becomes less scarce and its shadow price tends to fall, while that of the other input tends to rise. In this experiment, only two values of L_1 could be tested, but the stability of the shadow price of both primary inputs over a wide range of variation of F is reassuring. It should also be noted that when F=31·5 (the actual value of F in 1964), the variation in L_1 does not affect the values of the shadow prices.

The shadow price of the third primary input, total labour, is not shown in the table since it is zero for the relevant values of F and L_1. This result is to be expected; had it been otherwise it would have implied that a shortage of labour was restricting growth of output in the economy in 1964. At F=31·5, the shadow price of skilled labour is £1,700 per man year in 1956 prices. When expressed in 1964 prices this figure would be much higher than the actual average earnings of skilled labour, as defined for model purposes, in 1964. Taken together with the shadow price of total labour, one might conclude that it would have been worthwhile expanding labour training activities to convert unskilled into skilled workers. This is a restatement of the conclusions drawn from Table 3.1, above, about the effects upon the rate of growth of consumption and upon output of increasing the supply of skilled labour.

Since the actual rate of exchange between Irish pounds and pounds sterling was 1·0 in 1964, the shadow price of 0·8 for foreign exchange suggests that the Irish pound was actually slightly overvalued with respect to sterling. A possible explanation of this unexpected result is that the model assumes exports could have been increased without any loss in unit value. Taking into account this and other weaknesses of the model, the difference is hardly significant.

Sector Output Costs

The shadow cost of the output of each sector represents its unit cost of production in terms of the quantities and shadow prices of the primary inputs which it uses directly and indirectly. Differences which exist between the shadow cost of a sector's output and its market price can be attributed to the difference between that price and the opportunity cost of production.

If the shadow or opportunity cost exceeds the market price this implies that this sector is using more of the economy's scarce resources than is warranted by its value, whereas, if the market price is greater than the shadow price, then this implies that the market price is excessive. Since the nature

TABLE 3.8: SHADOW COSTS OF SECTOR OUTPUTS, 1964

	F=0		F=31·5		F=60·0	
L_1	236·9	256·9	236·9	256·9	236·9	256·9
1. Agric., Forestry and Fishing	0·5	0·5	0·5	0·5	0·6	0·5
2. Livestock Products	0·6	0·6	0·6	0·6	0·6	0·6
3. Crop Products	1·0	0·9	1·0	1·0	1·0	1·0
4. Drink	0·5	0·4	0·5	0·5	0·5	0·5
5. Tobacco	0·2	0·2	0·2	0·2	0·2	0·2
6. Textiles	0·8	0·8	0·8	0·8	0·8	0·8
7. Apparel	0·9	0·9	0·9	0·9	0·9	0·9
8. Wood and Paper	1·0	1·0	1·0	1·0	1·1	1·1
9. Chemicals	1·2	1·2	1·2	1·2	1·2	1·2
10. Metals and Machinery	1·1	1·1	1·1	1·1	1·1	1·1
11. Vehicles	1·0	1·0	0·9	1·0	0·9	0·9
12. Other Manufacturing and Mining	0·9	0·9	0·9	0·9	0·9	0·9
13. Construction	0·9	0·9	0·9	0·9	0·9	0·9
14. Electricity, Gas and Water	1·1	1·1	1·1	1·1	1·1	1·1
15. Transport and Trade	1·1	1·1	1·1	1·1	1·2	1·2
16. Services	1·4	1·3	1·5	1·4	1·6	1·5

of the model is such that each sector has an output price of unity, then the closer are the shadow prices to unity the more efficient is the sectoral allocation of resources. In interpreting the results, however, one should bear in mind that the model values resources used at their costs to the national economy (opportunity cost), and not to the individual industry, (market price).

Table 3·8 shows the shadow cost of each of the sixteen sectors of production for three selected values of F and two values of L_1. The stability of these prices, in the face of the range of the values of F is again reassuring. Secondly, it is noticeable that prices in all but five of the sectors are within 20% of unity. The low costs in sectors (1) and (2) can be attributed to the low content of skilled labour and imports which enters into agricultural output. Sector 16 has a high cost because of the high content of skilled labour in Services: this may be partly the result of our definition, but it also suggests that there may actually be a reservoir of skilled labour in this sector.[1] Since sectors (4) Drink and (5) Tobacco have, respectively, high skilled labour and import contents, one can only attribute the very low costs of production in these sectors to very high profits. This is an inference which anyone acquainted with these two industries would have no difficulty in accepting.

[1]The existence of such a reservoir in the U.K. was one justification for the Selective Employment Tax.

Summary of Results of the 1964 Projection

A number of tentative conclusions are indicated by the operation of our model in projecting the year 1964, using 1956 as a base.

(i) A faster rate of growth of consumption, national income and employment would have been attained over the period had the nation's resources been differently distributed. This result could have been achieved by a change in the composition of exports, consumption, and therefore of output.

(ii) Specifically, the 1964 projection suggests that too many scarce resources were devoted to the production of Vehicles, Wood and Paper, Construction, Electricity, Gas and Water, Transport and Trade and Services, and too few to Agriculture, Livestock Products, and Drink.

(iii) In some sectors, such as Textiles, Apparel and Metals and Machinery, the lower export share could have been offset by increased domestic consumption.

(iv) The supply of skilled labour provided the greatest limitation to increases in output. If the supply had been 10% greater this would have permitted a further increase in the annual rate of growth of consumption of 0·8%.

(v) When the exports of sixteen sectors of the economy are ranked in order of the ratio of their Domestic Factor Cost to Net Foreign Exchange Costs, Drink, Tobacco, Agriculture and Livestock Products are at the head of the list while Services, Metals and Machinery, Chemicals, and Electricity, Gas and Water are at the bottom, indicating that the Irish economy enjoys a comparative advantage in the former sectors.

(vi) The shadow prices calculated by the model suggest that the market price of skilled labour is too low, that of unskilled labour too high, and the par rate of exchange between the Irish pound and the pound sterling is about right.

(vii) The computed shadow sector output costs show that there are very low opportunity costs of production in Agriculture, Livestock Products, Drink and Tobacco, and that there is a very high cost of production in the Services sector, due to the skilled labour content.

(viii) Despite the simplicity of the model's structure and the weakness of the data, the results of the trial projection showed that it performed extremely well. When actual values of the exogenous variables F and L_1 were inserted in the model, the results were unexceptionably sensible, and when the values of F and L_1 were varied, the solutions proved quite stable.

The validity of these conclusions is examined in the next chapter by submitting the model to a further test.

4. FURTHER TESTS OF THE MODEL

At the beginning of the last chapter, it was stated that deficiencies in the data to which the model was applied might account for some of the differences between the results obtained from the 1964 forecasts and the actual 1964 values of the corresponding variables. The interindustry and import coefficients which were supposed to represent the economy in that year were only estimates based upon revisions of the 1956 data. It would not be surprising if the errors in these estimates should have affected the results of the model. The crucial question is: to how much did they affect the results?

An answer to this question can be found by repeating the experiments reported in Chapter 3, but this time applying the model to the year 1956. The solutions obtained will show what the levels and distributions of output and trade in the year 1956 would have been, if the resources available to the economy in that year had been allocated in such a way as to maximise total consumption. Since all of the data for the parameters and exogenous variables is drawn from 1956, there is no possibility of data errors. If the results which we obtain are broadly similar to those which were obtained from the 1964 "forecasts", then we can infer that any data errors did not affect the forecasts significantly.

Furthermore, the linear relations of the model are much more plausible as an approximation to reality in a cross-sectional rather than an intertemporal situation. Therefore, we can be reasonably confident that any deviations in the results of the 1956 model from the actual 1956 values must be attributed principally to a misallocation of resources in that year, and not to data errors or the structure of the model.

In the 1956 tests, which were less extensive for cost reasons, F was given five fixed values ranging from £–20·0 m. to £60·0 m., including the value of £16·4 m., which was the size of the current account deficit in the balance of payments in that year. The supply of skilled labour, L_1, was kept constant at its actual value.

Table 4.1 shows that the actual levels of Consumption, Employment and GNP realised in 1956 were each about 10% below the levels which they could have attained if resources had been differently distributed, assuming that the balance of payments deficit was to remain the same (F=16·4). This could have been achieved with a level of exports only 4% above their actual value. Alternatively, with the same level of employment and GNP as was actually achieved, a shift of resources from Consumption to Exports could have realised a balance-of-payments surplus of £20 million.

Table 4·2 shows the actual distribution of output by sector in 1956 together with the model solution for F=16·4. The proportion of total output devoted to Agriculture, Livestock Products, Drink and Tobacco is greater in the optimal solution than the actual share in 1956, while the share of the other sectors, notably Apparel, Construction, Electricity, Gas and Water, and Services is smaller.

Since the elasticity coefficients used to estimate the parameters of the household consumption functions were different in the two years, the optimal consumption pattern of 1956 cannot be used to confirm the optimal pattern of 1964.

A comparison of the optimal distribution of exports by sector in 1956, for F=16·4, with the actual distribution is shown in Table 4·3. This suggests that there should have been more exports of the output of sectors, Agriculture, Livestock Products, Drink and Apparel and Transport and Trade, and less of the other sectors.

The number of values of F was not sufficient to compute a ranking of sectors, but Table 4.3 confirms the comparative advantage which these sectors were found to have in the 1964 "forecasts". However, it was possible to record the pattern of Import Substitution in the three sectors, Drink, Tobacco and Vehicles.

TABLE 4.1: LEVELS OF PRINCIPAL VARIABLES, MODEL AND ACTUAL, 1956

	F	Total[1] Consumption	Total Employment	Total Exports	GNP[1]	Sum of Sector Gross Outputs
	£ m.	£ m.	(Thousands)	£ m.	£ m.	£ m.
Model	−20·0	352·6	965·2	203·2	483·4	794·5
	0·0	418·1	1,060·4	199·8	534·1	881·5
	16·4	434·3	1,057·7	184·3	533·7	878·6
	40·0	461·3	1,032·9	150·4	537·2	861·1
	60·0	469·1	1,030·0	150·4	524·1	862·3
Actual	16·4	390·2	965·5	176·9	485·8	799·4

[1]As defined for model purposes.

TABLE 4.2: DISTRIBUTION OF OUTPUT BY SECTOR, 1956, ACTUAL AND MODEL*

	£ m.		Per Cent	
	Actual	Model	Actual	Model
1. Agriculture	180·9	211·9	22·6	24·1
2. Livestock Products	58·9	69·6	7·4	7·9
3. Crop Products	58·9	59·7	7·4	6·8
4. Drink	31·6	38·5	4·0	4·8
5. Tobacco	31·0	38·1	3·9	4·3
6. Textiles	20·0	21·9	2·5	2·5
7. Apparel	32·4	31·0	4·1	3·5
8. Wood and Paper	29·1	31·7	3·6	3·6
9. Chemicals and Minerals	21·0	23·0	2·6	2·6
10. Metals and Machinery	18·4	21·3	2·3	2·4
11. Vehicles	16·0	16·8	2·0	1·9
12. Other Manufacturing and Mining	18·4	18·8	2·3	2·1
13. Construction	69·2	71·5	8·7	8·1
14. Electricity, Gas and Water	21·2	21·3	2·7	2·4
15. Transport and Trade	107·1	116·2	13·5	13·2
16. Services	85·3	87·3	10·7	9·9
Total 1–16:	799·4	878·6		
Total 1–14:	607·0	675·1		

*F=16·4.

TABLE 4.3: DISTRIBUTION OF EXPORTS BY SECTOR 1956, ACTUAL AND MODEL[1]

	£ million		Per Cent	
Sector:	Actual	Model	Actual	Model
1. Agriculture	48·6	58·3	34·3	39·2
2. Livestock Products	19·3	23·2	13·6	15·6
3. Crop Products	3·2	2·6	2·3	1·7
4. Drink	7·2	8·7	5·1	5·8
5. Tobacco	0·1	0·1	*	*
6. Textiles	3·6	2·8	2·5	1·9
7. Apparel	1·8	2·2	1·3	1·5
8. Wood and Paper	3·9	3·1	2·8	2·1
9. Chemicals and Minerals	1·4	1·1	1·0	0·7
10. Metals and Machinery	1·8	1·5	1·3	1·0
11. Vehicles	0·2	0·1	*	*
12. Other Manufacturing and Mining	3·4	2·7	2·4	1·8
13. Construction	—	—	—	—
14. Electricity, Gas and Water	—	—	—	—
15. Transport and Trade	7·6	9·1	5·4	6·1
16. Services	4·1	3·3	2·9	2·2
Tourism	35·4	30·0	25·0	20·2
Total	141·6	148·8	99·9	99·8

[1]F=16·4. *≤0·05.

TABLE 4.4: IMPORT SUBSTITUTION IN THE MODEL, 1956

F	Actual: 16·4	Model: −20·0	0·0	16·4	60·0
Drink R_4	0·7	1·4	1·4	1·4	0·2
Textiles R_6	2·7	5·3	5·3	5·1	0·0
Vehicles R_{11}	1·7	3·4	0·0	0·0	0·0

In Table 4.4, when the model values of R_i are greater than their corresponding actual values, this indicates that positive import substitution has occurred, whereas if R_i is less than the actual value, this means that there is negative import substitution. At the lowest value of F, there is positive import substitution in all these sectors. As F increases, negative import substitution occurs. First in Vehicles, then Textiles, then in Drink. Thus the 1964 pattern of import substitution is repeated.

TABLE 4.5: SHADOW PRICES OF PRIMARY INPUTS, 1956

F	−20·0	0·0	16·4	60·0	Units
Total Labour W_0	0·0	0·0	0·0	0·0	£ thousand per man year
Skilled Labour W_1	0·0	1·3	1·4	1·6	£ thousand per man year
Foreign Exchange q	4·6	1·0	0·9	0·4	Irish pounds per pound sterling.

Relations between F and C

From the data of Table 4·1 we can plot four points on the curve relating F and C (see Diagram 1) for the year 1956. The slope of this curve, representing the marginal productivity of foreign exchange, is broadly similar to the slopes of the corresponding 1964 curves.

Employment

We need not be detained by a comparison between the actual and the optimal sectoral distributions of employment in 1956. Since the labour coefficients are the same, except for Agriculture, where the labour coefficients were treated in the same way as they were in 1964, the difference between the two distributions reflects simply the difference in output distribution.

Shadow Prices of Primary Inputs

The shadow prices of the three primary inputs for four values of F are given in Table 4.5.

A comparison with Table 3.7 shows that for values of F corresponding to the actual deficits in the two years 1956 and 1964, (F=16·4 and 31·5 respectively) the shadow prices of the three primary factors are respectively 1·4, 0·9, and 0·0 in 1956 and 1·7, 0·8, and 0·0 in 1964. In both tests, the shadow price of skilled labour is very much higher than the market price, the shadow price of foreign exchange is just less than unity, and the shadow price of total labour is zero.

Shadow Costs of Sector Output

The shadow costs of the sector outputs in 1956 are shown in Table 4.6 for four values of F. It is clear that for all values except F=−20·0, the shadow costs are quite similar. At F=16·4, all but three of the sectors have shadow costs within 20% of unity, the three exceptions being Drink, Tobacco and Services. Their shadow costs were 0·4, 0·2 and 1·8 respectively. In Table 3·8, for F=31·5 and L=236·9 the corresponding costs are 0·5, 0·2 and 1·5. The two other sectors whose cost deviated more than 20% from unity in 1964 were Agriculture and Livestock Products, which have costs of 0·8 and 0·9 respectively in 1956.

TABLE 4.6: SHADOW COSTS OF SECTOR OUTPUT, 1956

F	−20·0	0·0	16·4	60·0
1. Agriculture	0·4	0·8	0·8	0·9
2. Livestock Products	0·6	0·9	0·9	0·9
3. Crop Products	1·2	1·0	1·0	1·0
4. Drink	0·5	0·4	0·4	0·4
5. Tobacco	0·7	0·2	0·2	0·1
6. Textiles	1·3	0·9	0·9	0·9
7. Apparel	0·8	0·9	0·9	0·9
8. Wood, Paper, Printing	0·6	1·0	1·1	1·1
9. Chemicals, Glass, Clay	1·6	1·1	1·1	1·0
10. Metals and Machinery	1·3	1·2	1·2	1·1
11. Vehicles	2·2	1·1	1·1	0·9
12. Other Manufacturing and Mining	1·4	1·0	1·0	1·0
13. Construction	0·7	0·9	0·9	0·9
14. Electricity, Gas, Water	2·1	1·2	1·2	1·0
15. Transport, Trade	0·7	0·9	0·9	0·9
16. Services	0·2	1·7	1·8	2·0

5. THE MODEL AND ECONOMIC PLANNING

At each stage of the construction and operation of the present model it was necessary to check the consistency of data coming from various sources. Consistency is one of the essential elements of any plan or forecast. As the degree of detail is increased it becomes desirable to devise some sort of data framework within which both the ingredients and results of the model might be recorded.

At the same time, there exist many items of information, originating from different sources, which relate to major features of the national economy. Frequently, the usefulness of these bits of information is diminished because differences in definition, rule out their being added to other bits of information. Since items of information are often defined peculiarly because they have been prepared for specific purposes, it would be wrong to imagine that all economic statistics should be made to conform to a single set of definitions. Nevertheless, if indicative planning is worth doing at all, it is worth doing well, and in that case it is clearly desirable to have a single data framework within which all of the items which are the concern of the national economic plan can be related. By creating a comprehensive but unified framework for data relating to different aspects of the economy, it may be possible to uncover some inconsistencies which would otherwise have passed unnoticed.

Thus the object is to provide a framework within which the various quantifiable targets of an Irish medium-term plan could be conveniently recorded. The basic framework is shown in outline in Diagram 2. Perhaps a few general remarks may be made before considering in turn each of the numbered cells in the diagram.

The framework is governed by two considerations —the usefulness of the specified variables and the availability of statistics. Of these two, the former is the predominant one, since if a particular variable is agreed to be useful, it is expected that an effort could be made to get the appropriate estimates. It should be said at once that it will not be necessary, for most purposes, to try to fill in all of the numbered cells in the diagram.

What then, are the specific purposes for which the framework is suited? When the projected values for some future year (let us say, 1975) have been filled in, they can be used to make the same types of analysis which it would be possible to make for some past year, given historical data of that year set out as in the diagram. For example, analysis of the import and employment implications of different patterns of final demand, analyses of changes in relative prices, wages, and taxes, etc., etc.

From the planning point of view, the actual specification of values in the framework for the future year would be the principal function. These are the targets to which expectations will be directed. How are these targets to be determined? Diagram 2 is merely an accounting framework, without any explicit functional relations.

The quantitative targets of the Second Programme —in their final form—were arrived at by a two-stage process in which values calculated by an analytical model were compared with estimates agreed with representatives of various sectors of the economy. It seems probable that Third Programme targets will be reached by a similar process. If this is the case, then the proposal outlined here constitutes a framework within which data could be recorded before and after revision.

The actual outline of the framework shown comes

from sources too numerous to mention, but the bones of Diagram 2 are similar to the structure suggested by Gigantes and Pitts.[1]

Table 1 is the familiar interindustry table, showing the flows of current goods among the domestic sectors of productions. Table 2 shows the principal commodities which are the output of the different sectors of production. This kind of data is presently collected by the Census of Industrial Production, as is the information required for Table 6, the different commodities used by each sector of production. The significance of the information contained in these two tables is that it may be used in conjunction with assumptions suggested by Stone to compute estimates of inter-commodity relations, which may be more useful for certain purposes than the usual interindustry relations. Since the number of commodities distinguished is likely to be greater than the number of sectors, Tables 2 and 6 are both rectangular.

Table 3 shows the current consumption of the output of domestic sectors of production by private households, institutions, and non-production government activities. A glance at the 1960 input-output table shows that households and government accounted for the consumption of £476 m. of domestic output whereas interindustry uses accounted for only £296 m. So far as the data permit consumption can be broken down into separate columns for farm families, non-farm families, institutions and government activities classified by function, e.g. health, roads, etc. The data for Table 3 are likely to be adapted from Table 7, since consumption data relate to commodities rather than industries. Tables 4 and 8 show the capital goods produced by the Irish economy, classified respectively by sector of origin and by type of goods. The column classification for both tables might contain the following headings as a minimum: Plant and Equipment, Non-residential Building, Housing, All Other Construction and Works, and Net Change in

[1]T. Gigantes and P. Pitts, "An Integrated Input-Output Framework and Some Related Analytical Models", paper presented at the Conference on Statistics, University of British Columbia, June 1965, mimeographed, Dominion Bureau of Statistics, Ottawa.

DIAGRAM 2: OUTLINE OF MEDIUM-TERM PLANNING FRAMEWORK

	Domestic Industries 1 .. n	Domestic Commodities 1 .. m	Private and Public Consumption 1 .. g	Private and Public Investment 1 .. j	Exports 1 .. f	Imports	Totals
Domestic Industries 1 . . . n	1	2	3	4	5		
Domestic Commodities 1 . . . m	6		7	8	9		
Value Added	10		11	12	13		
Imports (Commodities) 1 . . . k	14		15	16	17		
Totals							
Capital Goods 1 . . . g	18			19			
Labour 1 . . . h	20		21	22			

Stocks. Tables 5 and 9 would normally form a single column, in which the data of 5 will be a rearrangement of data obtained from the Trade Statistics, recorded in 9. However, f categories have been written in to provide for separate area markets. The second last column in the framework sets out those imports which are judged to compete with domestic production, classified by sector and then by commodity.

Tables 6 and 9 have been mentioned. Table 10, really a single row, shows the value added in each sector of production. The framework represents primarily real flows, and value added is included only for the sake of completeness. Value flows play a minor role within the framework for two reasons. First of all, projections at base year prices are more easily made for real flows. Secondly, over a planning period of several years, technical or behavioural relations among variables are more important than accounting relations which involve purely value flows.

Tables 11, 12 and 13 are a continuation of the Value Added row, and represent the values added in consumption, investment, and export activities respectively.

Table 14 is a table of imports showing the imported goods of different types currently consumed by the various domestic sectors of production. According to the choice of classification for imports, this table may show all such imports, or only those which are judged to be noncompeting. Table 15 shows the imports absorbed by households and the other final consumption categories, while imported capital goods are recorded in Table 16 under the appropriate categories of capital formation. Re-exports are shown in Table 17.

A capital goods flows matrix is shown in Table 18. The row totals of this table equal the sum of the row totals of Tables 8 and 16. The total of each column in the table represents the total value of additions to the capital stock of the corresponding domestic sector in the year in question. If a table such as this were to be compiled, then it would be possible to construct a dynamic multisectoral model. Otherwise, the more modest goal could be attempted of estimating the total capital stock, or the additions thereto, of each sector of domestic production.

The last row of tables shows the distribution of labour between the various sectors of production, consumption, and investment. If labour is defined simply in numbers or in manhours, Tables 20, 21, and 22 will constitute segments of a single row. However, it is likely that labour can be divided into various categories distinguished by skill, age or occupational status. Thus each of these three tables will have as many rows as the available data permits, and so far as these distinctions are useful.

This framework contains the data for the principal variables and parameters of the model described in Chapter 2. To obtain values of the endogenous variables for the end year of the plan, one would first have to make independent projections of the exogenous variables and of the parameters. Once this task has been completed, the model can be used to generate, not just a single set of values for the endogenous variables, but, as Chapter 3 has shown, as many solutions as are desired corresponding to a chosen range of values of the predetermined variables.

6. MATHEMATICAL FORMULATION OF THE MODEL

The endogenous variables of the model are:

X_i = Output of sector *i*.

C_i = Consumption by households of the output of sector *i*.

I_i = Capital goods produced by sector *i*.

E_i = Exports of goods and certain services by sector *i*.

T_i = Receipts of sector *i* from Tourist and Travel expenditures.

$-S_i$ = Imports competing with the output of sector *i*.

C_m = Consumption by households of noncompeting imports.

C = Total household consumption.

I_m = Imports of noncompeting capital goods.

I = Total investment.

E = Total Exports.

M = Total Imports.

Y = GNP.

${}_1I$ = Investment in Plant and Equipment.

${}_2I$ = Nonresidential Building.

T_m = Tourist purchases of noncompeting imports.

T = Total level of Tourist and Travel expenditure.

The exogenous variables of the model are:

G_i = Current government purchases of the output of sector *i*.

N = Total population.

L_0 = Total supply of labour.

L_1 = Total supply of skilled labour.

F = Net capital inflow from abroad.

${}_3I$ = Investment in Housing.

$_4I$ = All other Construction and Works.

$_5I$ = Total Stock Change.

V_E = Net factor income from abroad.

V_I = Value added in investment.

G_m = Current government purchases of non-competing imports.

G = Total current government expenditure.

The parameters of the model are:

p_t = Price index for Tourist and Travel expenditure.

p_v = Price index for net factor income from abroad.

r_{mj} = Amount of noncompeting imports of capital goods used per unit level of investment activity, $_jI$.

r_{ij} = Amount of capital goods of type i used per unit level of investment activity $_jI$.

t_i = Amount of sector i output used per unit level of tourist activity.

a_{ij} = Amount of output of sector i used to produce one unit of output of sector j.

e_i = Elasticity of household demand for output of sector i.

s = Aggregate marginal propensity to save.

k_{ij} = Amount of investment of type i required per unit of output of sector j.

l_{sj} = Amount of labour of type s used per unit of output of sector j.

m_j = Amount of noncompeting imports used per unit of output of sector j.

d_i = Ratio of price of competing import i to domestic cost of production.

p_m = Price index of imports.

p_i = Price index of exports of sector i.

e_m = Elasticity of household demand for non-competing imports.

The Model

Total household consumption is maximised

(0) $C_1+C_2 \ldots +C_n+C_m = \text{Max.}$

Subject to the following constraints:

(a) Output Determination

(1) $X_i-\sum_j a_{ij}X_j-C_i-I_i-E_i-T_i-S_i \geqslant G_i \qquad (i=1, 2 \ldots 16)$

(b) Household Consumption

(2) $C_i=e_i\frac{C^\circ_i}{C^\circ}C-\frac{N}{N^\circ}C^\circ_i\,(e_i-1) \qquad (i=1,2\ldots16)$

(3) $C_m=e_m\frac{C^\circ_m}{C^\circ}C-\frac{N}{N^\circ}C^\circ_m\,(e_m-1)$

(4) $C=\sum_i C_i+C_m$

(5) $C-(1-s)Y \geqslant -G+C^\circ+G^\circ-(1-s)Y^\circ$

(c) Investment

(6) $I_i=\sum_j r_{ij}\,{}_jI \qquad (i=1, 2 \ldots 16)\,(j=1 \ldots 5)$

(7) $I_m=\sum_j r_{mj}\,{}_jI$

(8) $I=\sum_i I_i+I_m+V_I$

(9) $_jI=\sum_i k_{ij}X_j$

(d) Imports

(10) $M=\sum_j m_jX_j+C_m+I_m+T_m+G_m-\sum_j d_iS_i \qquad (j=1, 2 \ldots 16)$

(11) $\bar{S}_i \geqslant S_i \geqslant \underline{S}_i$

(e) Exports

(12) $\bar{E}_i \geqslant E_i \geqslant \underline{E}_i \qquad (i=1, 2 \ldots 16)$

(13) $T_i=t_iT$

(14) $\bar{T} \geqslant T \geqslant \underline{T}$

(15) $E=\sum_i E_i+T+V_E$

(f) Foreign Exchange

(16) $P_m{}^M-\sum_i p_iE_i-p_tT-p_vV_E \leqslant F$

(g) Labour

(17) $\sum_j l_{sj}X_j \leqslant L_s \qquad (s=0, 1)\,(j=1, 2 \ldots 16)$

(h) GNP Determination

(18) $Y=C+I+G+E-M$

Variables which are written with circular superscripts denote particular values of the variables, e.g. G° denotes a specific value of G. Bars written above and below variables denote respectively upper and lower bounds on their values.

The foregoing is a perfectly general formulation of the model; in practice, not all of the variables or equations necessarily are used.

Household Consumption

Equations (2) represent the linear approximation to the slope of the curve:

$$C_i/N = k(C/N)^{e_i}$$

at the point $(C^{\circ}/N^{\circ}, C^{\circ}_i/N^{\circ})$ on the curve.

$$C_i/N = f(C/N) = k(C/N)^{e_{i-1}}$$

$$\therefore f^1(C/N) = e_i k(C/N)^{e_i - 1}$$

$$= e_i[k(C/N)^{e_i}(C/N)^{-1}]$$

$$= e_i[C_i/N.N/C]$$

$$= e_i C_i/C$$

The slope of the tangent at point $C_i = C^{\circ}_i$, $C = C^{\circ}$, is $e_i \frac{C^{\circ} i}{C^{\circ}}$.

Writing α for $\frac{N}{N^{\circ}} C^{\circ}_i(e_i - 1)$

and β for $e_i \frac{C^{\circ}_i}{C^{\circ}}$.

then the ith equation of system (2) can be written

$$C_i = \beta C - \alpha$$

Foreign Trade

It is a well known principle of linear programming that when any activity X_j is in the optimal solution the value of resources used to produce one unit of j must be at least as great as the contribution of a unit level of the activity to the objective. When a foreign trade activity in our model, T_r, lies between its upper and lower bounds, $\overline{T}_r$ and $\underline{T}_r$, it is marginally profitable. It will be recalled from Chapter 3 that as F increases, first one foreign trade activity, then another moves, *in turn*, from its upper bound to its lower bound. Given a sufficient number of observations of F, foreign trade activities can be ranked according to the values of F above which they cease to be profitable. It can be shown that this ranking is determined by the ratio of the value of domestic resources to the net value of foreign exchange earned (in the case of export activities) or saved (in the case of import substitution activities). It can be further shown, that in the case where there are only two effective scarce resources (i.e. only two with nonzero shadow prices), that this ranking is independent of changes in factor endowments. In this case—which is that of the present model—the ranking depends entirely on the total (direct and indirect) coefficients of resource input to each trade activity. Thus, the exports of each sector of the economy can be ranked in an order which is determined by the relative factor intensity of the output of the sector, in the case in which there are only two factors of production. Where there are effectively more than two factors, the ranking of exports changes according to changes in the supply of resources. The optimal pattern of foreign trade, as determined by the model, is therefore generated by a process which is an empirical analogue of the Hekscher-Ohlin theorem on the pattern of a country's foreign trade:

Let T_r = level of trade activity T

w_o = shadow price of labour

w_1 = shadow price of skilled labour

q = shadow price of foreign exchange (number of Irish pounds per pound sterling)

V_r = foreign exchange revenue per unit of activity r

μ_r = total (direct and indirect) import coefficient per unit of activity r

λ_{or} = total labour coefficient per unit of activity r

λ_{1r} = total skilled labour coefficient per unit of activity r.

Then, when the value of resources used per unit of trade activity r is just equal to its contribution to the objective function.

$$w_o\lambda_{or} + w_1\lambda_{1r} + q(\mu_r - V_r) = 0$$

$$\therefore q = \frac{w_o\lambda_{or} + w_1\lambda_{1r}}{V_r - \mu_r}.$$

Now let

$$\frac{w_o\lambda_{or} + w_1\lambda_{1r}}{V_r - \mu_r} = \phi_r$$

ϕ_r = ratio of the actual domestic resource cost to net foreign exchange earned per unit of activity r.

When $\phi_r = q$, the operation of the rth trade activity is just profitable, i.e.

$$\bar{T}_r > T_r > \underline{T}_r.$$

When $\varnothing_r > q$, i.e. the exchange cost is greater than the rate of exchange then the activity is not profitable, and

$$T_r = \underline{T}_r.$$

When $\varnothing_r < q$, then the activity is definitely profitable and

$$T_r = \bar{T}_r.$$

Thus the point at which activity r leaves its upper bound as F increases (and q diminishes) depends on $\varnothing_r$.

Suppose $w_o = O$, then

$$\varnothing_r = w_1 \frac{\lambda_{1r}}{V_r - \mu_r}$$

While w_1 may vary, it cannot affect the relative ranking of $\varnothing_r$ and $\varnothing_{r+1}$. Consequently, in the case where there are only two resources, $\varnothing_r$ depends entirely on λ_{ir}, V_r and μ_r, which are known functions of the parameters of the model.

7. SOURCES AND METHODS OF DATA PREPARATION: 1964 TEST

1. Sector Output

Estimates of Gross Output in 1964 at 1956 prices, according to I-O definitions of output, were obtained for each of the 16 sectors of production by multiplying the 1956 sector outputs (obtained from I-O table) by index numbers of volume of output. The index numbers were derived as follows:

Sector 1: Index for volume of Gross Output of Agriculture including value of change in livestock numbers, excluding turf. (*ISB*, June 1966, p. 95.)

Sectors 2-14: Index Numbers of Volume of Industrial Production for CIP industries were taken from *ISB* September 1966, p. 190, and aggregated by weighting the index for component industries by Net Output, 1960, to make indexes for these sectors.

Sectors 15 *and* 16: The items "Distribution, transport, and communication" and "Other domestic" in Table 22 of *NA* 1965 were used to measure the increase in volume of output of Sectors 15 and 16, respectively, from 1958 to 1964. To get from 1958 to 1956, it was necessary to take NNP by sector of origin at current prices for the same two items (*SA* 1961, p. 260), and deflate the increase in value by a price index of 106. The latter is based on an assumed price rise of 3 percentage points per annum, which is close to the increase in the official CPI item, "Other goods and Services" from mid-May 1956 to mid-May 1958.

2. Household Consumption

The objective is to form estimates of household consumption of the output of each sector i, in 1956 prices, and of noncompeting imports. These estimates, C°_i and C°_m, can then be used as the reference points for the tangents to the Engel curves. In conjunction with the comparable data for 1956 they can be used to estimate e_i. Thus we can obtain the parameters α and β of our consumption equations.

UNYNAS 1965, pp. 178-9, gives estimates of 15 items of consumption expenditure at current prices and of fewer items at constant prices for the years from 1956 to 1964. Neither the definition of consumption nor the classification of items in that publication conform to the definition or classification used in the model. Nevertheless, we select from this data factors with which to make a preliminary projection of the 1956 input-output data to 1964. At the same time we make an independent projection of Total Consumption by multiplying Total Consumption for model purposes in 1956, (see Sources and Methods: 1956), by the index number of private consumption expenditure derived from *UNYNAS* 1965, p. 174. A first revision is made of some of the elements of the projected consumption column to ensure that the column adds to its independently projected total. A second revision is made when a row balance is worked out for each sector. As a result of these revisions, estimates of C°_i and of C°_m are obtained and thence estimates of e_i.

The derivation of the e_i for Sector 5 Tobacco is an illustration of the hazards of both the method and the data. It is clear from the 1956 I-O Table and from data for 1964 prepared by NIEC that the principal consumption of Tobacco is that by households and tourists. Since competing imports are negligible, this means that an index of the volume of domestic production of tobacco products should approximately be equal to an index of domestic consumption. In fact, taking 1956 as 100, the index of volume of production in 1964 (CIP) stands at 92·5 while the index of consumption for the same year is 100·1, (*UNYNAS*, p. 179, Table 7, item 3). In such cases of conflicting information the volume of output index is preferred as being more reliable. Note that the differences between the elasticities used in the two tests did not prevent a broad similarity of results.

TABLE 7.1: COEFFICIENTS OF ELASTICITY OF HOUSEHOLD DEMAND USED IN MODEL, 1956 AND 1964 TESTS

Sector	1956	1964	Sector	1956	1964	Sector	1956	1964
1	·58	·44	7	·65	1·18	13	1·06	1·03
2	·58	·44	8	2·27	·98	14	·49	·74
3	·58	·44	9	1·06	2·06	15	1·0	·98
4	·86	·28	10	2·27	3·08	16	1·61	·78
5	·86	−·74	11	2·27	2·83	Noncompeting Imports	2·27	2·39
6	1·06	1·18	12	1·06	2·14			

3. Investment

(a) Investment by Sector of Use

Table 5 on pp. 176-7 of *UNYNAS* 1965, provides the framework for our estimates. This table shows investment by type of capital and by major branch of activity in both constant and current prices for both years 1964 and 1956. Thus, it not only provides control totals for our estimates, but also allows us to derive price indexes with which to deflate 1964 values to 1956 prices. The data in the table for the year 1964 are incomplete, but the latest estimates were kindly provided by CSO.

Sector 1: CSO provided a breakdown of investment in Agriculture, Forestry and Fishing between Machinery, and Buildings and Other Investment in current 1964 prices. The first two items were deflated by the appropriate price indexes (see below), and divided by the preliminary estimates of Sector 1 output to form the coefficients for Sector 1 of Plant, Equipment and Buildings, respectively.

Sectors 2-14: A comparison of total investment in Manufacturing, Mining, Construction, and in Electricity, Gas and Water as recorded by the CIP with that shown in the *UNYNAS* shows that there are small discrepancies in Mining and Construction, but that in Manufacturing and Electricity, Gas and Water, the data are identical. This means we can use the unadjusted CIP for the latter sector, while for the former we "blow up" the CIP estimates, so that they add to the *UNYNAS* totals. Specifically, the *Plant and Equipment* estimates are formed by aggregating the data shown in *ISB*, December 1966, p. 273, *et seq.*, Table 12, column 1, "Increases in Fixed Capital Assets During the Year 1964—Cost of Plant, Machinery and Vehicles", while the *Building* estimates are formed from column 2 of the same table, "Increases in Fixed Capital Assets—Cost of Buildings and Other Construction Work". The data are then deflated, and the coefficients formed by dividing by the sector output estimates. When compared with coefficients prepared on a similar basis for the years 1956 and 1960, it turns out that they are quite stable.

Sectors 15 *and* 16: Estimates for these sectors are obtained residually. We know the total capital investment in each sector, and we also know the remaining plant and equipment and buildings expenditure which has not been allocated to Sectors 1-14. We distribute this residual by setting up the following table:

TABLE 7.2: DISTRIBUTION OF RESIDUAL INVESTMENT EXPENDITURE, 1964

	Total Investment	P+E	Building	Other
15. Transport and Trade	30·9	p	q	r
16. Services	16·0	s	t	u
Total	46·9	19·9	6·9	20·1

In order to solve for the unknowns . . . p, q, r, s, t and u, it is necessary to make two assumptions: we assume that

$$\frac{p}{q} = \frac{19{\cdot}9}{6{\cdot}9} \quad \text{and} \quad \frac{q}{t} = \frac{30{\cdot}9}{16{\cdot}0}$$

The system can then be solved, and the coefficients derived from p, q, s, and t in the usual manner.

Price Indexes: The price index used to deflate all 1966 Plant and Equipment expenditures to 1956 prices is the weighted sum of the implicit price indexes for items *d*, Transport Equipment and *e*, Machinery and Other Equipment derived from *UNYNAS*, pp. 176-177 and from CSO. The price index used to deflate all 1964 Building expenditures to 1956 prices is the weighted sum of the implicit price indexes for Item *b*, Non-residential Buildings and *c*, Other Construction and Works derived from the same sources. The resulting indexes had the 1964 values respectively of 115·0 and 127·5, (1956 = 100).

(b) Investment by type of asset

The control totals for our five investment activities are derived from *UNYNAS*, pp. 176-177, by converting investment by type of capital good at 1958 market prices to 1956 market prices, using the same price indexes for each type of good implicit in the same table:

TABLE 7.3: GROSS DOMESTIC CAPITAL FORMATION 1964, IN 1956 PRICES. £m.

1. Plant and Equipment	62·7
2. Buildings, non-residential	26·4
3. Housing	21·4
4. All Other Construction and Works	27·1
5. Changes in Stock	10·5
Total	148·1

The totals of the first two activities are, of course, equal to the sum of Plant and Equipment expenditures and of Buildings, respectively, which we have just calculated for each sector of production as described in (*a*) above. This leads to an underestimate of the value of the building coefficients in the residually estimated sectors 15 and 16, since the CIP data used for estimating "Building" Expenditures includes some expenditure on other construction.

The next step is to estimate the elements of the column representing each investment activity: these elements represent capital goods used by each activity and the column sum is equal to the control totals of the investment activity $_jI$. When the elements of each of the columns are added by row the row sums are equal to the total of capital goods, I_i, produced by the sector of production *i*.

Plant and Equipment Column

We assume that the proportion of the elements in this column has not changed since 1956 (see Sources and Methods: 1956). This assumption was checked first with the Noncompeting Import coefficient. It has been assumed that all noncompeting imports of capital goods (in 1956) were imports of plant and equipment, forming about 30% of total P+E expenditure. If noncompeting imports of capital goods increased at the same rate as did all imports of capital goods between 1956 and 1964, then the coefficient would remain unchanged, since this rate corresponded almost exactly to the rate of increase of total P+E expenditure. The check of the row balance of each sector suggested one change in the column: the contribution of row 11 was reduced, and an equal amount was added to row 12.

Non-Residential Building and Housing

These activities have only a single entry in their columns, representing deliveries from the Construction sector.

All Other Construction and Works

The coefficients in this column were assumed unchanged from 1956.

Stock Changes

The total stock change is distributed by the National Accounts between (i) Agriculture, Forestry, Fishing, (ii) Mining, Manufacturing and Construction and (iii) Other. After deflating the NA data to 1956 prices, (i) is allocated to Sector 1, while (ii) is distributed among Sectors 2-18 according to the CIP data "Stocks of goods made by establishments", p. 270 of *ISB*, December 1966. Other Stock Changes (iii) are allocated entirely to Sector 15 since the CIP shows that stock changes in Sector 14 are negligible while those in 16, Services, are nonexistent. No estimate was attempted of changes in the stocks of imported goods.

4. Exports

The three principal components of export earnings are (i) Tourism and Travel Receipts, (ii) Net Factor Income from abroad and (iii) Exports of Goods and Other Services. The source of estimates for all of these components is the Balance of Payments Table A19 on p. 60 of *NA* '65.

(i) *Tourism and Travel.* The control total for this activity is the item "Receipts in respect of tourism, travel, etc." in Table A19. The coefficients of the column are derived from the "Invisible Exports" column in the 1960 I-O Table, adjusted to remove non-Tourist invisible exports.

(ii) *Net Factor Income from Abroad.* Includes all other items on both sides of the current external amount, except "Merchandise" and "Other known Current".

(iii) *Exports of Goods and Other Services.* From the item "Merchandise Export" in Table A19 is subtracted the total exports by All Industry shown in NIEC "Statistical Summary of Industrial Reviews", 1966. The remainder is allocated to Sector 1. Neither the Merchandise Exports item nor the NIEC data include exports of Shannon Industrial Estate, estimated to amount to £16·5 million in current 1964 prices. (This figure and its breakdown was kindly provided by J. Blackwell.) However, net exports from Shannon (i.e. Exports-Imports) are included in the item "Other known Current" in Table A19. An estimate of this figure (6·0 million) was subtracted from that item; the remainder of "Other known Current" was allocated to Sector 16. Exports of Sector 15, other than those included under Tourism and Travel, and before adjustment from f.o.b. to producer's prices were assumed to be zero. The next step is to add to the NIEC data of exports by Sectors 2-14, the exports by Shannon, broken down by sector. When this has been done, the column of Exports by the 16 sectors of production is converted from f.o.b. to producer's prices by assuming a uniform trade and transport margin of 6·4 per cent on all exports. This figure was based upon the Merchandise Export Column in the 1960 I-O

table; the sum of the margins subtracted from each sector was allocated to Sector 15. Finally, all of the values, hitherto at 1964 prices, were converted to 1956 prices by deflating by price indexes for each sector. Upper and Lower Bounds for Exports were calculated by adding and subtracting 20 per cent to these values.

Export Price Indexes

(i) *Tourism and Travel*: The control total for this item is deflated by the Consumer Price Index All Items for mid-May 1956 and 1964.

(ii) *Net Factor Income from Abroad*: This item is not deflated, since the equation in which it appears is expressed in 1964 prices.

(iii) *Exports of Goods and Other Services*:

Sector 1: An index is derived of the unit value of Live Cattle and Calf Exports for the years 1956 and 1964, taken from the *ISB*, June 1958, p. 78, and *ISB*, June 1966, p. 97, respectively. The index for 1964 is 131·8 (1956=100). A calculation of the same unit value index for other years between 1956 and 1964 shows that it appears to rise steadily throughout the period.

Sector 2-14: It was decided to use output price indexes to deflate the exports of these sectors. Indexes were obtained for each sector by dividing the index of value of gross output (CIP) by the index of volume of gross output, from the same sources.

Sectors 15 *and* 16: Price indexes for the items "Distribution, Transport and Communication" and "Other Domestic" are implicit in Tables 8 and 11, NA '65. These indexes were extended back to 1956 by assuming a 3 per cent per annum price increase between 1956 and 1958, as explained in Section 1 above.

When each sector has been deflated, the total of Exports of Goods and Other Services 1964 at 1956 prices is £195·4 million. The corresponding total in current 1964 prices is £240·0 million which suggests an aggregate price increase of 22·8 per cent. This can be compared to an increase of 15·5 per cent in the Official Domestic Export price index (All Items), between the two years.

5. Imports

Imports are divided into two categories in the model: Competing Imports, which appear as a column, and Noncompeting Imports, which are entered as a row. The distinction between Competing and Noncompeting is laid down by the 1956 I-O Table, and, until the 1964 Table becomes available, there is no information which will suggest directly how the elements of the Competing Imports Column and the Noncompeting Import row can be estimated with any accuracy for 1964. The criteria in preparing such estimates is the avoidance of inconsistency and unreasonableness.

To the "Merchandise Import" item in Table A19, NA 1965, we add £8·5 million for Imports into Shannon (see 4, Exports, above), the Tourist and Travel Payments Abroad item, and "Other Current" import items to give the Total Imports of Goods and Non-Factor Services for model purposes. Each of these items is deflated; Merchandise Imports by the Official Import Price Index (All Items), (104·1 in 1964 when 1956 is 100), and the other two by the Consumer Price Index (All Items) (127·5 in mid-May 1964 when mid-May 1956 is 100).

The noncompeting import coefficients in the 1956 table were increased, arbitrarily, by 10 per cent. When multiplied by the estimates of sectoral output this provides an estimate of interindustry consumption. Consumption of noncompeting imports by households, investment, tourism, and Government is then estimated by multiplying the estimated levels of these activities by the corresponding coefficients, whose derivation is described above in the relevant sections. The result is a preliminary estimate of Total Noncompeting Imports. When this figure is subtracted from Total Imports, the remainder is Competing Imports. The residual was compared with another estimate of Competing Imports obtained by assuming that these imports increased from 1956 to 1964 at the same rate as did the output of the domestic sectors of production with which they were competing. This discrepancy between the two estimates amounted to about 10 per cent. The distribution of competing imports by sectors was carried out by comparing the residual column of a row balance calculation, (see Section 7 below), with the column obtained by assuming an increase in competing imports proportional to domestic outputs. Where the two estimates were similar, then the residual value was accepted for that sector. Where they deviated, it was clear either (i) that competing imports had increased much more or much less than output or (ii) that adjustments were necessary in other elements of the row in question. In choosing between (i) and (ii), the changes in NIEC estimates of competing imports by sector from 1960 to 1964 were taken into account. Although the NIEC definition of competing imports was much narrower than that adopted in the 1956 table, (and thus in the 1964 model), it was thought that the NIEC data might suggest the direction and the relative magnitude of import substitution by sector.

6. Government Expenditure

The definition of government expenditure for purposes of the 1964 model is the same as that used for the 1956 test (q.v.). The elements of the column

of government expenditure for 1964 were obtained by multiplying the corresponding elements of the 1956 column by 1·097, an index of the volume of net government expenditure on current purchases of goods and services formed from *NA* 1956, Table 17 and *NA* 1962, Table A4.

7. Interindustry Coefficients

The coefficients used in the model for 1964 are those for 1956 with the following adjustments:

Row 1: All coefficients reduced by 7·2 per cent
Row 6: All coefficients increased by 32·7 per cent
Row 9: All coefficients increased by 27·8 per cent
Row 10: All coefficients increased by 39 per cent
Row 11: Diagonal coefficients increased by 30 per cent
Row 14: All coefficients increased by 100 per cent
Row 15: All coefficients reduced by 6·9 per cent.

These adjustments were brought about as a result of working out row balances for each sector. As described above, estimates were made of all final demands for a sector's output. Intermediate demands were calculated using the 1956 coefficients: the resulting total demand should be equal to the total supply, i.e. domestic sector output plus competing imports. If the discrepancy was large, and it could not be attributed to competing imports, or to apparent deficiencies in the estimates of any of the elements of final demand, then the adjustment was made on the interindustry demands, by changing the coefficients.

8. Labour

The Total Labour Force consists of all those aged 14 years and over who are gainfully occupied. Subtracting those who are engaged in economic activities outside the scope of the model, (see Classification, Appendix I), gives the total labour supply for purposes of the model. Subtracting from this figure the numbers who are out of work leaves the total numbers of people who must be divided among the 16 sectors of the model.

Sectors 1, 13 *and* 14: The numbers engaged in these sectors are taken from the corresponding Items of Table 9, *Review of* 1966 *and Outlook for* 1967, Pr. 9372.

Sectors 2-12: CIP data on numbers engaged in each sector are adjusted upwards by using the ratio of numbers engaged in that sector in 1961 according to CIP and the numbers engaged in that sector in 1961 according to the 1951 Census of Population, Vol. IV, Table 3. The sum of the estimates for Sectors 2-12 is equal to the total numbers engaged in Manufacturing and Mining as shown in Table 9 of Pr. 9372.

Sectors 15 *and* 16: The numbers engaged under the headings of the Transport, Trade and Service items in Table 9 are distributed among the model sectors 15 and 16 and omitted services according to the proportions obtaining in the 1961 Census of Population.

The following methods were used to designate "skilled" labour:

Sector 1: The fraction of the total labour force engaged in Sector 1 in 1964 designated as skilled was equal to the ratio of the number of farmers engaged on farms of more than 100 acres to the total number of persons engaged in Agriculture as reported in the 1961 Census of Population, i.e. a ratio of 6·6 per cent.

Sectors 2-14: The "skilled" labour in each sector is defined as the sum of three categories.

(1) All Salaried Persons.
(2) Those Wage-Earners with a rate of weekly-earnings of £16 or over in a payweek in October 1964.
(3) One-third of the numbers excluded from the CIP but included in the Census of Population.

The source of (1) was the Census Industry reports published in the *ISB* in 1965 and 1966. The source of (2) was *ISB* December 1966, pp. 278-80. (3) was obtained from a comparison of the Census of Population, Vol. VI, Table 3 with the CIP returns reported in the *ISB*.

It is arguable that the cut-off weekly earnings rate to designate a skilled worker should have been placed higher than £16. Unfortunately, the relevant table has not kept pace with inflation, and shows no higher earnings range than £16 or over.

Sectors 15 *and* 16: Table 6 of the 1961 Census, Vol. IV shows the principal occupation within each industry. The following Occupational Codes were taken as "Skilled".

020 Glass Formers, 028 Radio and TV Mechanics, 031 Electricians, 036 Riveters, 039 Fitters and Mechanics, 040 Plumbers, 044 Watchmakers, 045 Goldsmiths, 046 Carpenters, 048 Sawyers, 105 Foremen and Supervisors, 148 Commercial Travellers, 179-206 Professional and Technical Workers, 178 Directors, Managers and Company Secretaries, 140 Proprietors, 141 Managers and Buyers, 142 Publicans, 154 Hotel Managers (male), 115 Engine Drivers, 116 Guards, 118 and 125 Railway and Bus Inspectors.

Particularly *excluded* were:

124 Lorry and Van Drivers, 138-139 Clerks and Typists, 136 Warehousemen, "Other" of all categories, 140 Female sub-postmistresses, 150 Insurance Agents.

The major problem is Occupational Code 140, Proprietors. In Grocery Retailing, they account for approximately 10,000 out of about 24,000 engaged. Also, out of 12,282 males engaged in motor garages,

7,510 are listed as Fitters, Assemblers and Mechanics.

9. Other

The estimate of GNP 1964 at 1956 prices for model purposes is obtained by applying to the 1956 definition of GNP an index of GNP at constant market prices derived from the 1965 and 1962 *NA*. The index is such that when 1956 = 100, then 1964 = 126·3. This independent estimate of Y means that the exogenous elements G and V_E (part of E) are determined residually from Equation (18).

8. SOURCES AND METHODS OF DATA: 1956 TEST

10. Sector Output

The outputs of each sector represent the Gross Domestic Outputs of the 36 sectors of the 1956 Input-Output Table aggregated to 16 sectors according to the classification shown in Appendix I. The version of the 1956 Input-Output Table which was used is reprinted in the *Journal of the Statistical and Social Inquiry Society of Ireland*, Vol. XXI, Part III, facing p. 64. (This table contains some printing errors.)

11. Household Consumption

The control total for C° was formed from the Households column in the 1956 I-O Table as follows:

	£m.
Total Interindustry Purchases	394·3
Less Omitted services	−17·8
Plus Non-competing imports	+13·6
Equals Total Household Consumption for model purposes	390·1

The elements of the Households column, aggregated to 16 sectors, provide the C_i° for 1956; in order to form the parameters α and β of the consumption equations it is also necessary to have estimates of the elasticity coefficients, e_i. In his paper "The Pattern of Personal Expenditure in Ireland", *Journal of the Statistical and Social Inquiry Society of Ireland*, Vol. XXI, Part II, C. E. V. Leser presents three sets of estimates of income elasticities of demand for eight commodity groups. In Table 5 he shows two sets, intertemporal (1953–61), cross-sectional (1951-52) and in Table 6 a set of judgmental estimates (1960-70). Because of the nature of the 1956 model the cross-sectional elasticities were used, with the exception that the coefficient for Sector 7 was determined residually at 0·65, instead of the value of 1·51 suggested by Leser, while the coefficient for Sector 15 was fixed at 1·0. The coefficients used are shown in Table 7.1 above.

12. Investment

Estimates of the control totals of the five investment activities were derived from *UNYNAS* 1965, p. 176, Table 5, the National Accounts 1962 and columns 40, 41 and 42 of the 1956 I-O Table. The data used in the model were as follows:

		£m.
Gross Domestic Capital Formation 1956, current prices.		82·6
Less Value of Changes in Stocks (−8·0)		8·0
Equals Gross Domestic Fixed Capital Formation		90·6
of which Plant and Equipment Expenditure	31·0	
Non-residential buildings	16·7	
Housing	19·7	
All Other Construction and Works	23·2	

The elements of the columns were estimated as follows:

Plant and Equipment Expenditures: The entries in rows 19, 20, 21 and 25 of columns 40 and 41 of the 1956 Table were allocated to this column, as were the non-competing import entries in those columns. This means assigning the output of capital goods produced by the Metals, Machinery and Vehicles sectors to this activity, and assuming that all imports of non-competing capital goods were of plant and equipment.

Non-residential Buildings and Housing: There is only one entry in each of these columns, representing an input from the Construction sector equal in value to the activity control total.

All Other Construction and Works: All the remaining elements in columns 40 and 41 not already allocated to the three foregoing investment activities were assigned to this activity.

Stock Changes: The elements of this column are aggregated directly from the elements of column 41 in the 1956 Table. The column is equal to the interindustry total of column 42 *less* Sales to Final Buyers.

Estimates of the input coefficients for the two investment rows, Plant and equipment and Building were prepared in the following way:

Sector 1: The total investment in Agriculture, Forestry and Fishing shown in *UNYNAS* 1965 was

divided between Machinery, Building and Other on the basis of informations, kindly provided by E. Attwood of An Foras Talúntais.

Sectors 2-12: CIP data on gross investment in New Plant and in New Buildings and Land obtained from NIEC were aggregated to 16 sectors. These figures were then increased by multiplying by the ratio of the UN total of Gross Fixed Capital Formation in Manufacturing and Mining, 1956, to the corresponding CIP total. The figures were then divided by sector output to give coefficients for each of the two categories of investment in 1956. An exactly similar procedure was followed to calculate the same coefficients for 1960. The coefficients for sectors 2-12 actually used in the 1956 model represent the arithmetic mean of the coefficients for 1956 and 1960.

Sectors 13 *and* 14: Estimates of investment in Plant and Equipment and in Building were obtained by distributing the total investment in each of these sectors (*UNYNAS* 1965) in the proportions shown by the CIP data (*ISB*, September 1959).

Sectors 15 *and* 16: The residual investment expenditures of the two categories were divided among the two sectors by a procedure similar to that described in Section 3 (*a*).

13. Exports

Column 43 of the 1956 Table is first divided into two columns: Merchandise Exports and Invisible Exports, using the proportions shown in the 1960 Table. The Communications and Finance row entries in column 43 are transferred from the Invisible column to the Merchandise Export column, and the two columns become respectively the Tourist and Travel Activity column and the Exports of Goods and Other Services column. The total of the Tourist column, £35·4 m., can be compared to the figure of £31·3 m., shown in the Balance of Payments Table A19 in NA 1962. The adjustment is made on the item "Balance unaccounted for", so that the total Current Accounts Exports as defined in the Balance of Payments is reconciled with the estimates derived from the input-output table. The principal export variables in the 1956 model are:

	£m.
Tourism and Travel Activity	35·4
Net Factor Income from Abroad	34·0
Exports of Goods and Other Services	107·5
Total, Exports for model purposes	176·9

14. Imports

The control totals of Competing and Non-competing Imports and their distribution between sectors are taken from the 1956 Table. The total for Import earnings on current account, according to the I-O Table differs from that shown in the National Accounts, so that the current account deficit for model purposes is £16·4 m. in 1956, compared to the official estimate of £14·4 m. (Table A19 *NA* 1962).

F, the net capital inflow, is defined as the Gross Capital Inflow *plus* Increases in External Assets *less* the Gross Capital Outflow *less* Reductions in External Assets. It is equal to the deficit in the Balance of Payments on current account.

15. Government Expenditure

The control total for Government expenditure for model purposes is equal to the total of column 39 of the 1956 Table *less* Taxes, Profits, Depreciation, etc., *less* Omitted Services.

16. Labour

Total Labour Force for model purposes is equal to Total Numbers Gainfully Employed *less* numbers engaged in Omitted Services. The former item is defined in 1956 as the mean values of the Labour Force totals in 1951 and 1961, according to the Census of Population 1961, (numbers of persons over 14 gainfully occupied). The latter item is identified from the same Census, Vol. IV, Table 3. The number out of work in 1956 is estimated as the difference between the total labour force and the numbers engaged in the different sectors. These are estimated as follows:

Sector 1: The figure for 1956 is taken as the mean value of the 1951 and 1961 Census of Population data for those engaged in Agriculture, Forestry and Fishing. (Vol. IV, Table 3.)

Sectors 2-14: The estimates for each sector are equal to the numbers engaged according to the CIP 1956, multiplied by the 1961 ratio Census of Population/CIP estimate of numbers engaged for that sector.

Sectors 15 *and* 16 *and Omitted Services:* The mean values of the 1951 and 1961 Census of Population are again used for these sectors.

The Total Supply of "Skilled" Labour is defined as the sum of the numbers of "Skilled" workers engaged in each sector. These are estimated as follows:

Sector 1: The ratio of the number of farmers on farms of more than 50 acres according to the 1961 Census of Production to the Total Numbers engaged in Agriculture in the same census, is applied to the Total Labour estimated to be engaged in Sector 1 (see above) in 1956.

Sectors 2–14: Skilled labour in each sector is measured as the sum of the following three categories:

(1) All Salaried Employees, according to CIP 1956.

(2) Numbers of Wage-Earners with rate of weekly earnings of £10 or over in a pay-week in October 1956 (*ISB*, September 1959, pp. 206-209).

(3) $\frac{1}{3}$ of those excluded from CIP but included in Census of Population.

Sectors 15, 16 and Omitted: The estimates obtained from the 1961 Census of Population which were used for 1964 were used in 1956.

17. Other

The total GNP for model purposes, £485·8 m., is simply the sum of the principal expenditure components C, G, I, E and M. Of these G and C differ the most from their corresponding National Accounts aggregates, as a result of the exclusion of certain Services, taxes and other items. The National Accounts figure for GNP is £559·3 m.

9. CONCLUSIONS

If the planning model had been a positive rather than a normative one, it would have been a simple matter to have tested it directly by applying it to the period 1956-1964 and comparing the forecast values for 1964 with the actual values. Testing the present model is more difficult because differences between forecast and actual 1964 values reflect differences between an efficient and the actual allocation of resources as well as deficiences in the data and in the model. However, this model provides more information than any positive model could. Specifically, it computes:

(*a*) efficient and consistent programmes for the distribution of capital, two types of labour, imports exports, output and employment between sectors,

(*b*) relationships between the principal macro-economic variables, National Income, Employment, Consumption, and the Balance of Payments Deficit.

(*c*) shadow prices for the primary inputs and opportunity costs for the output of each of the sectors of production.

As a by-product the model also provides a comparative advantage ranking of sectors for foreign trade.

The model was used to generate efficient programmes for 1964 taking 1956 as the base-year, and the results were described in Chapter 3. The scope for errors is diminished when 1956 is used as both the base-year and the target year for the model and the results of this test, described in Chapter 4, can be used as a check of the 1964 test. The following results of the 1964 test are confirmed by the 1956 test:

(i) With the supplies of labour and capital actually available and the same balance of payments deficit, levels of Consumption and National Income about 10% higher than the actual could have been realised by a redistribution of resources.

(ii) A more efficient allocation of resources in the Irish economy implies greater exports from the sectors, Agriculture, Livestock Products, Drink, and Tobacco and accordingly, a greater share of the nation's scarce resources, capital, skilled labour and imports being allocated to them. Increases in the share of these sectors in national output would take place at the expense of Construction, Electricity, Gas and Water, Transport and Trade, and Services.

(iii) The supply of skilled labour provides the greatest limitation to increases in output. The 1964 projection suggests that a 10% increase in the supply of skilled labour in that year would have permitted a further increase in the annual rate of growth of consumption of 0·8% between 1956 and 1964.

(iv) The shadow prices calculated by the model suggest that the market price of skilled labour is too low, that of unskilled labour too high and that the par rate of exchange between the Irish pound and the pound sterling is about right.

(v) There are large returns over cost in the Drink and in the Tobacco sectors, (which may have been paid out in the form of higher profits and/or wages than elsewhere), while a reservoir of skilled labour exists in the Services sector.

(vi) The transformation curve between the Net Capital Inflow and Total Consumption is concave to the origin and of decreasing slope.

(vii) When actual values of the exogenous variables, F, the Net Capital Inflow, and L_1, the supply of skilled labour, were inserted in the model, the results were unexceptionably sensible; and when the values of F and L_1 were allowed to vary, the solutions proved to be quite stable.

These conclusions illustrate both the strengths and weaknesses of the model. They may appear to many to be self-evident. If this is so, then it is one of the strengths of the model, because the purpose of carrying out a test projection is to see how well it reflects reality. Others will find in the results implications for development policy which may or may not accord with their predilections. For them, it is worth emphasising once more that the results of the model cannot be applied to the real world automatically but require interpretation.

During the period 1956-1964, official development policy in Ireland was of the type which was classified in Chapter 1 of this paper as "industrial export promotion". The results of the model projection over this period are neutral with respect to the efficiency of industrial development but suggest that too few resources were allocated to the "traditional" industries—Agriculture, Livestock Products, Drink, and Tobacco and too many to what we may call the "infrastructural" industries—Construction, Electricity, Gas and Water, Transport and Trade, and Services.

So far as these issues of development policy are concerned, the model has two obvious limitations. First, it does not take into account that increasing *employment* is an important *objective* of policy. Secondly, it assumes that the sales of each sector can be increased without falling unit revenues, i.e. that there is a perfectly elastic demand for each sector's output. When these limitations are remembered, the policy implications of the model are less dramatic; what remains is the inference that further increases in the output of the traditional industries can be achieved at very little cost to the rest of the economy. In other words, it may be possible to develop the newer industries *and* the traditional ones *at the same time*.

The findings of the shadow price calculations for total labour and for skilled labour have obvious implications for incomes policy and for labour training activities. The large returns over cost in the Drink and Tobacco industries suggest that some attention might be given to finding ways of increasing the exports and output of these industries. Conversely, there is a pool of skilled labour in the services sector which might be tapped by other sectors to the benefit of the economy as a whole.

The tests of the model, while confirming its operational usefulness, have revealed a number of areas for improvement. Most important is the estimation of better labour input functions which would relate output and employment in each sector and the introduction of export demand functions to represent conditions of inelastic demand. Other improvements include disaggregation, a supply function for foreign exchange to represent the cost of foreign borrowing, and the incorporation of investment and perhaps employment variables in the objective function. None of these improvements, with the possible exception of the last, presents any theoretical difficulties: the only limitation is the time required to compile the necessary information.

Appendices

CLASSIFICATION OF SECTORS

Model Sector	Industries Included in Sector
1. Agriculture, Forestry and Fishing	Agriculture; Government Forestry; Fishing
2. Livestock Products	Bacon Factories; Other Meat Slaughtering; Creameries
3. Crop Products	Grain milling; Bread, biscuits etc; Sugar; Cocoa, chocolate etc; Canning Fruit and Vegetables etc; Canning and preserving of fish; Butter blending etc; Miscellaneous Food preparations.
4. Drink	Distilling; Malting; Brewing; Aerated Waters
5. Tobacco	Tobacco
6. Textiles	Woollen and Worsted; Linen and cotton spinning etc; Jute, canvas, rayon etc; Made-up textile goods.
7. Apparel	Hosiery; Boots and Shoes; Men's and boys' clothing; Women's and girls' clothing; Shirt-making; Miscellaneous Clothing.
8. Wood, Paper and Printing	Wood and Cork; Furniture and Fixtures; Brushes and brooms; Paper and products; Printing and publishing.
9. Chemicals, Glass and Clay Products.	Fertilisers; Oils, paints etc; Chemicals and Drugs; Soap etc; Glass, pottery etc; Structural clay products; Cement.
10. Metals and Machinery	Metal Trades; Electrical Machinery; Non-Electrical Machinery.
11. Vehicles	Ship Building; Railroad equipment; Road and land vehicles; Other vehicles.
12. Other Manufacturing and Mining.	Miscellaneous Manufacturers; Mining, Quarrying and Turf; Fellmongery; Leather products.
13. Construction	Building and Construction by private contractors; by Local Authority and Government Departments; by canal authorities; by railway companies; Other building etc.
14. Electricity, Gas and Water	Electricity; Gas Works; Waterworks
15. Transport and Trade	Wholesale and Retail Trade; CIE; Taxis and car-hire firms; Private hauliers; Air companies; Sea Transport.
16. Services	Communications; Finance; Education, Health and Vet. Services; Other Professions; Hotels and Restaurants; Amusements and Recreations; Laundries and Hairdressing; Other Industries.
Activities which are *omitted* from the model.	Ownership of Dwellings; Public Administration and Defence; Domestic Service; Other Personal Services; Sales by Final Buyers.

APPENDIX TABLE 1: SELECTED SOLUTIONS B (L_1=256·9) FOR THE MAJOR AGGREGATE VARIABLES

F	C	E	M	Y	I	Unused Labour (thousands)
−50·0	435·3	404·6	335·5	626·0	146·1	137·8
−27·5	490·9	404·6	356·8	669·3	155·1	60·7
−20·8	502·5	404·6	363·1	677·0	157·5	45·3
−11·6	512·3	396·2	363·8	678·1	157·3	42·9
1·7	524·5	390·3	370·8	680·4	158·4	37·5
12·7	533·7	381·8	373·2	681·0	158·8	36·4
37·0	552·8	362·2	377·6	681·1	159·6	33·2
44·2	558·4	355·6	378·2	680·4	159·6	35·5
58·5	569·4	353·0	389·3	677·0	158·7	42·5
66·6	574·6	344·7	389·1	676·2	158·3	42·2
91·0	589·1	322·9	391·6	667·6	157·8	55·1
100·0	593·1	315·8	393·3	664·2	157·6	59·7

Note: Values of E are in 1964 prices; all others (except Labour) are in 1956 prices.

APPENDIX TABLE 2: SELECTED SOLUTIONS A (L_1=236·9) FOR THE MAJOR AGGREGATE VARIABLES

F	C	E	M	Y	I	Unused Labour (thousands)
−30·0	464·4	396·2	346·4	639·4	149·2	112·1
−19·2	474·4	390·3	351·1	641·6	150·1	107·3
−8·4	483·4	381·8	353·3	642·2	150·4	105·6
7·3	495·7	369·0	356·1	642·2	150·9	103·4
15·9	502·4	362·2	357·6	642·3	151·2	102·3
25·5	510·0	353·0	358·1	641·1	151·0	105·8
36·5	518·3	353·0	368·5	638·8	150·7	111·0
44·4	523·5	345·8	369·2	637·6	150·0	111·4
62·4	534·3	329·4	370·7	631·5	149·6	120·3
70·8	539·1	322·9	372·5	628·3	149·3	124·0
80·0	543·1	314·5	373·2	625·0	149·2	129·4

Note: Values of E are in 1964 prices; all others (except Labour) are in 1956 prices.

APPENDIX TABLE 3: SECTOR OUTPUT LEVELS, 1964

ACTUAL VALUES AND MODEL SOLUTIONS A AND B FOR F=31·5

Sector	Actual (L_1=236·9)	Model	
		(L_1=236·9)	(L_1=256·9)
		A	B
1. Agriculture, etc.	218·2	254·0	263·9
2. Livestock Products	100·5	117·4	119·4
3. Crop Products	71·4	71·6	76·6
4. Drink	33·9	37·9	38·8
5. Tobacco	28·7	29·9	28·7
6. Textiles	33·9	35·6	57·5
7. Apparel	49·8	53·1	60·8
8. Wood and Paper	41·7	40·8	45·4
9. Chemicals and Minerals	38·3	39·7	44·4
10. Metals and Machinery	50·1	50·1	64·1
11. Vehicles	29·9	28·3	33·6
12. Other Manufacturing and Mining	39·6	43·4	51·9
13. Construction	88·6	90·7	94·0
14. Electricity, Gas, and Water	36·0	35·5	38·5
15. Transport and Trade	138·9	133·2	143·5
16. Services	102·6	97·6	102·9
Total	1,102·1	1,158·8	1,264·0

APPENDIX TABLE 4: DIRECT COEFFICIENTS OF INPUTS OF LABOUR, INVESTMENT AND IMPORTS INTO EACH SECTOR, 1956

Sector	Total Labour	Skilled Labour	Plant and Equipment	Buildings	Noncompeting Imports
1. Agriculture	1·845	·353	·021	·020	·011
2. Livestock Products	·173	·051	·015	·007	·029
3. Crop Products	·463	·114	·030	·010	·111
4. Drink	·297	·085	·040	·010	·041
5. Tobacco	·090	·035	·008	·001	·142
6. Textiles	1·060	·164	·054	·011	·126
7. Apparel	1·037	·238	·009	·006	·013
8. Wood and Paper	·924	·306	·044	·012	·029
9. Chemicals and Minerals	·662	·195	·059	·026	·169
10. Metals and Machinery	1·054	·321	·043	·023	·132
11. Vehicles	·975	·300	·016	·011	·374
12. Other Manufacturing and Mining	1·071	·293	·066	·033	·183
13. Construction	1·185	·259	·017	·010	·033
14. Electricity, Gas and Water	·566	·231	·289	·094	·198
15. Transport and Trade	1·685	·376	·073	·023	·068
16. Services	1·843	1·150	·021	·048	·008

APPENDIX TABLE 5: DIRECT COEFFICIENTS OF INPUTS OF LABOUR, INVESTMENT, AND IMPORTS INTO EACH SECTOR, 1964

Sector	Total Labour	Skilled Labour	Plant and Equipment	Buildings	Noncompeting Imports
1. Agriculture	1·210	·106	·036	·032	·012
2. Livestock Products	·120	·032	·015	·006	·032
3. Crop Products	·373	·112	·050	·014	·122
4. Drink	·260	·115	·045	·020	·045
5. Tobacco	·077	·035	·010	·008	·156
6. Textiles	·493	·086	·037	·009	·139
7. Apparel	·719	·137	·027	·007	·014
8. Wood and Paper	·607	·228	·050	·013	·032
9. Chemicals and Minerals	·433	·149	·111	·022	·186
10. Metals and Machinery	·514	·144	·042	·014	·145
11. Vehicles	·368	·151	·013	·020	·411
12. Other Manufacturing and Mining	·533	·169	·077	·077	·201
13. Construction	·813	·164	·029	·022	·036
14. Electricity, Gas and Water	·306	·144	·309	·053	·218
15. Transport and Trade	1·312	·426	·096	·032	·075
16. Services	1·548	·735	·064	·021	·009

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