

AGRICULTURAL
ECONOMICS
RESEARCH UNIT



Lincoln College

THE OPTIMISATION
OF A SIXTEEN SECTOR
MODEL OF THE
NEW ZEALAND ECONOMY

by

T. R. O'MALLEY

*

Research Report No. 67

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THE AGRICULTURAL ECONOMICS RESEARCH UNIT

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P R E F A C E

The Agricultural Economics Research Unit has carried out a considerable amount of research over the last few years into interindustry relationships in the New Zealand economy. In this Research Report, Mr O'Malley describes a linear programming model of the New Zealand economy which is based on the Unit's earlier work. Some of the results and comments may have been overtaken by events, but the value of the Report lies in its demonstration of how a model of this type can be used to investigate the implications of a range of different conditions imposed on the economy. In interpreting any of the results, Mr O'Malley's comments on the exploratory nature of this study should be kept firmly in mind.

J.D. Stewart

Lincoln College,
January, 1973.

CONTENTS

	Page
I. INTRODUCTION AND SUMMARY	1
II. OUTLINE OF THE MODEL	4
III. THE MODEL IN PRACTICE	7
IV. RESULTS AND INTERPRETATION	12
A. The Linear Programming Solution	12
B. Discrete Variations in some Parameters	34
REFERENCES	69
APPENDIX	70

LIST OF TABLES

Table		Page
I	Linear Programming Tableau	11
	Key to Rows of Table I	11a
IIA to IIF	Optimum Solution	17 - 22
IIIA to IIIF	Effect of Changes in Assumptions) of Model)	23 - 28
IV	Economic Structure of New Zealand) Economy 1972/73 : Linear) Programming Model)	31
V	Economic Structure of New Zealand) Economy 1972/73 : Lincoln) Projection Model)	32
VIA to VIF	Optimum Solutions for Fluctuating) Terms of Trade for Primary Products)	38 - 43
VIIA to VIIF	Optimum Solutions for Varying Export Limits	45 - 50
VIII A to VIII F	Optimum Solutions with 10 per cent) Increase in Technological Efficiency) of Capital and Labour in some Sectors)	54 - 59
IXA to IXF	Optimum Solutions with Variation in) Minimum Consumption Requirements) for Immigrants)	61 - 66

OPTIMISATION OF A SIXTEEN SECTOR MODEL OF
THE NEW ZEALAND ECONOMY¹

I. INTRODUCTION AND SUMMARY

The purpose of this paper is to report on the empirical application of a linear programming model of the New Zealand economy, and to draw some conclusions which may be of use to national policy makers. Although the mathematical structure of the model and its relationship to economic theory have been described in detail elsewhere,² a general description is given in Section II for the sake of completeness, and this should be sufficient for readers primarily interested in the quantitative results and their implications.

The principal conclusions that can be drawn from the analysis regarding medium and long term economic development in New Zealand are as follows:

(1) Given that expansion of markets for manufactured goods will be difficult, it is important that markets for primary products exported from New Zealand should be maintained and that investment in farming should continue at a high level so that the current high standard of living in New Zealand should not deteriorate. This policy should apply even when agricultural export prices are low. The economy is particularly

¹ The assistance of Professors B.P. Philpott and B.J. Ross is gratefully acknowledged. Responsibility for the results presented and the conclusions drawn is, however, solely the author's.

² O'Malley [6], Philpott & O'Malley [8] .

sensitive to the loss of markets for processed primary products.

(2) Expansion of the economy and improvement in living standards are more dependent on the encouragement of new products and new industries than on traditional ones. In particular, serious efforts should be made to find further export markets for processed forestry products and for secondary manufactured products.

(3) An intensive immigration policy would not be of immediate benefit to the economy. Additional labour is required, but it is only after export markets have expanded that the economy is likely to be able to stand the additional pressure on foreign exchange (as well as on other resources). At the same time a small amount of immigration is recommended. It stands to reason that, where possible, the immigrants admitted should have skills in industries which have export potential.

(4) There should be some encouragement of import substitution industries which will significantly ease the balance of payments. This should not, however, at least on existing evidence, be a major policy priority.

Perhaps the most important comment which should be made with respect to this investigation concerns the limitations of the study. A number of theoretical and practical shortcomings associated with the linear programming technique are cited elsewhere.¹ However, the author's view is that the most serious difficulties are related to the quantity, quality and timing of data available. By comparison, many of the theoretical objections to the use of programming techniques

¹ See O'Malley [6].

(and input-output models in general), are small in importance or can be assuaged by making appropriate approximations. It goes without saying that more detail and more accuracy of data would be helpful, but perhaps these problems are overshadowed by the considerable time lag that exists between the publication of data that is available and the moment at which that data is in a suitable form to speculate about the future. As things stand the future is more often the present and in some cases the past by the time analytical results are available to policy makers. Consequently, this study must be regarded as exploratory. The author is of the opinion that a model of this nature is only of real use if the component parts can be assembled quickly. For this reason interindustry analysis should no longer be a one-man occupation, but be carried out by a team. This would tend to speed up the data assembly operation, and a very important fringe benefit would be a tendency towards greater accuracy and detail.

II. OUTLINE OF THE MODEL

Previous work at Lincoln has demonstrated the use of input-output projection models for "indicative planning" of the national economy.¹ Briefly, these models are used to calculate a structure of the economy (levels of output for each sector, levels of exporting by each sector, levels of investment by each sector and levels of importing by each sector) given a level of aggregate private consumption which is desired by, or likely to be achieved in, some target year. The outstanding feature of input-output models, which were developed first in the 1940s by Wassily Leontief, is that they account for economic interdependence between the productive sectors of the economy. However, policy makers may be more interested in the economic structure which will give the greatest level of consumption in the target year, given the resources of the nation.

Linear programming provides a means by which this may be done. The technique is, in the simplest terms, a mathematical routine which chooses levels for specified variables within a number of specified constraints so as to maximise a specified objective. It is possible to view the levels of output, investment and exports for all sectors of the economy as the variables, the total availability of resources as constraints, and the sum of private consumption and government expenditure as the objective to be maximised. Consider the following verbal description of the model.²

¹ Philpott & Ross [9], Ross & Philpott [10].

² The model is described formally and in greater detail in another publication [6]. The original structure has been slightly modified, however. Details of the changes are outlined in Section III.

(a) Definition of variables

- (i) Current production activities: the values of these variables in any solution represent the gross outputs of the sectors of the economy.
- (ii) Net investment activities: these variables represent the levels of net investment that will be necessary in the sectors in the target year if growth in the economy is to continue.
- (iii) Consumption activity: this variable represents the level of private consumption plus government expenditure.
- (iv) Exporting activities: these variables represent the level of exporting (valued f. o. b.) from the sectors. Only sectors producing goods have exporting activities; trade, transport and storage margins are accounted for in the coefficients of the variables.
- (v) An immigration activity: this activity enables the projected labour force for the target year to be extended.

(b) Objective Function

The objective of the model is to maximise consumption in the target year.

(c) Restrictions

The model contains a number of linear constraints which express as closely as possible resource availability in the economy.

- (i) Current production reconciliation: these restrictions exist for each commodity produced and ensure that the total use of any commodity does not exceed the total amount available.
- (ii) Balance of payments row: this constraint ensures that the level of importing in the target year does not exceed

current export earnings by more than a specified acceptable deficit.

- (iv) Savings row: before investment can take place savings must occur in the economy. In this model savings are assumed to bear a fixed relationship to aggregate public and private consumption.
- (v) Labour constraint: this constraint ensures that the sum of the labour required by all the sectors does not exceed the labour force plus immigration.
- (vi) Constraints on exporting activities: each of the exporting variables is restricted to a specified maximum. This represents the fact that export earning potential for any commodity is not unlimited.

This model requires interindustry statistics: current input-output coefficients, capital input-output coefficients, import-output coefficients, capital-output ratios, labour-output ratios, and estimates of the potential size of export markets and the terms of trade for various groups of products. From the earlier projection work carried out at the Agricultural Economics Research Unit, a pool of such data, based on 16 sectors, is available for the March year 1964/65.¹

¹ Ross and Philpott [11], Francis [1] .

III. THE MODEL IN PRACTICE

The initial linear programming tableau for the model in its present form is laid out in Table I. A few modifications have been made from the basic outline that has already been described:

(1) A Consumption Activity for Immigrants

It is generally agreed that consumption per head, while not without its shortcomings, is a more satisfactory policy goal than total consumption. However, the presence of an immigration activity in the model means that total population is endogenous, so that consumption per head cannot be calculated using a linear equation. Consequently, activity P_{45} , consumption by immigrants, has been added to the model so that the maximisation of consumption per head might be at least approximated. This is achieved by forcing the economy to "set aside" a minimum amount of consumption for every thousand immigrants admitted and optimising the level of consumption for the original population. Thus an additional row, R_{44} , is required:

$$0 \cong 1.0 P_{44} - 1.0 P_{45}$$

This restriction ensures that the economy generates at least \$1 m. of the consumption "basket" for each 1000 immigrants; i. e. \$1000/head is laid down as a minimum acceptable level of income for immigrants.

At first sight this seems to be a rather callous approach to the problem and there may be cries of "slave labour". However, the failure to adequately or even partially ensure reasonable living standards for immigrants has been a major cause of unrest in some countries. No claim is made that the model does anything to distribute income among the population, and it is very likely that in a real situation immigrant workers would receive a share of the maximand. The formulation avoids the possibility that the model will program massive immigration to achieve massive levels of output and total consumption, but very low per capita consumption.

(2) Autonomous Investment

It was recognised in the Lincoln projection work that capital-output ratios were not a satisfactory way of handling all forms of investment.¹ The idea of "autonomous investment" was, therefore, also used in this model for some investment by government and investment in houses. This has resulted in the addition of two investment activities, P_{31} and P_{33} , for which there are minimum levels for the target year. These activities are not activated via capital-output ratios in the same way as the other investment activities, e. g.

$$228 \cong 1.0000 P_{31}.$$

This constraint states that the investment activity P_{31} must be at least at the level of \$228 million in the target year. The coefficient for P_{31} is 1.0000 rather than 6.6667 as the constraint is concerned only with the final year's investment flow; the size of the relevant capital stock is not of direct concern to the planning model. An additional production activity has also been added. This is due to the fact that some of the capital used by the "Ownership of Property" sector is not housing but premises rented to productive sectors, and the requirement of this type of capital should be decided within the model by a capital-output ratio. Thus there are two activities for this sector, P_{16} and P_{17} . P_{16} is used only by productive sectors; P_{17} is used only by final demand.

(3) Import Substitution of Consumption Goods

As in the five sector pilot example several consumption alternatives are available to the economy.² It would, of course, be more satisfactory to have separate activities for the importing of each commodity defined for the study, but due to data difficulties

¹ Ross & Philpott [10], p.115.

² See O'Malley [6], Philpott & O'Malley [8].

it would not be possible to do this without a large preliminary study.¹ Nevertheless, the "Other Manufacturing" sector includes the production of most items for which the import substitution dilemma is relevant. Therefore, two consumption activities, P_{35} and P_{36} , in which the import coefficient has been reduced by 5 per cent and 10 per cent respectively, have been included - the differences from the original value have been added on to the requirement for "Other Manufacturing". It would, perhaps, be desirable to provide similar import substitution alternatives for each of the productive activities, but substitution of imported final goods was considered to be more likely in the short term. That is, if economic forces and trade barriers permit, industries which assemble imported components will become established more easily than industries which manufacture the components.

(4) Depreciation

Depreciation is handled as described in Technical Paper No. 16 [6], but the additions to the current input-output coefficients were weighted so that a unit of replacement capital contained a lower proportion of "Building and Construction" than a unit of net investment capital. This was an attempt to allow for the fact that buildings are more durable than plant and machinery so that on average, expenditure on replacement will have a lower proportion of building than expenditure on net investment. However, the durabilities of all capital goods vary considerably, so that this can only be considered a partial solution to the problem.

The time horizon chosen was eight years. This is similar to time periods used in other linear programming studies.² In this

¹ A comparison of different methods of treating imports and a summary of the data position in New Zealand is contained in O'Malley [7], ch. II.

² See, for example, Manne [2].

case eight years was convenient for the additional reason that the results could be compared with the Lincoln model projections for 1972/73.

In all other respects the linear programming tableau follows the format outlined in Technical Paper No. 16.

Activities $\underline{P_1}$ to $\underline{P_{17}}$ are current production activities.

Activities $\underline{P_{18}}$ to $\underline{P_{33}}$ are net investment activities.

Activities $\underline{P_{34}}$ to $\underline{P_{36}}$ are indigenous population consumption activities.

Activities $\underline{P_{37}}$ to $\underline{P_{43}}$ are exporting activities.

Activity $\underline{P_{44}}$ is an immigration activity.

Activity $\underline{P_{45}}$ is an immigrant's consumption activity.

Activity $\underline{P_{46}}$ is a total consumption activity.

Rows $\underline{R_1}$ to $\underline{R_{17}}$ are current production reconciliation rows.

Rows $\underline{R_{18}}$ to $\underline{R_{33}}$ are capital stock reconciliation rows.

Row $\underline{R_{34}}$ is a foreign exchange reconciliation row.

Row $\underline{R_{35}}$ is a savings reconciliation row.

Row $\underline{R_{36}}$ is a labour-force restriction.

Rows $\underline{R_{37}}$ and $\underline{R_{43}}$ are maximum restrictions on the levels of the exporting activities.

Row $\underline{R_{44}}$ sets a minimum consumption requirement for immigrants.

Row $\underline{R_{45}}$ computes the level of total consumption.

Definitions of the sixteen sectors, and the linear programming activities and restrictions, as well as a description of the compilation and sources of data are given in an appendix at the end of this report.

Key to Rows in Table I

- | | |
|-------------------------------|---------------------------------------|
| 1. Farming | 24. Other Mfg. Capital |
| 2. Forestry | 25. Building & Construction Capital |
| 3. Forestry Processing | 26. Public Utilities Capital |
| 4. Hunting & Fishing | 27. Transport & Communication Capital |
| 5. Mining | 28. Distribution Capital |
| 6. P.P.P. | 29. Banking & Insurance Capital |
| 7. Other Manufacturing | 30. Services Capital |
| 8. Building & Construction | 31. Min. Government Investment |
| 9. Public Utilities | 32. Ownership Capital |
| 10. Transport & Communication | 33. Min. Ownership Investment |
| 11. Distribution | 34. Foreign Exchange |
| 12. Banking & Insurance | 35. Savings |
| 13. Services | 36. Labour |
| 14. Services to Households | 37. Max. Farming Exports |
| 15. Services to Government | 38. Max. Forestry Exports |
| 16. Ownership (interindustry) | 39. Max. Forestry Proc. Exports |
| 17. Ownership (final demand) | 40. Max. H. & F. Exports |
| 18. Farming Capital | 41. Max. Mining Exports |
| 19. Forest Capital | 42. Max. P.P.P. Exports |
| 20. Forest Proc. Capital | 43. Max. Other Manufacturing Exports |
| 21. H. & F. Capital | 44. Min. Immigration Consumption |
| 22. Mining Capital | 45. Total Consumption Reconcil. |
| 23. P.P.P. Capital | |

IV. RESULTS AND INTERPRETATION

A. The Linear Programming Solution

(1) The Optimal Solution:

The linear programming problem depicted in Table I was solved on an IBM 1130 computing system. The particular numerical values chosen were thought to correspond fairly closely to the set of assumptions used in the projection work reported by Ross & Philpott [10], and hence to those thought appropriate by the Targets Committee to the National Development Conference [12]. This applies especially to the exporting limits used, many of the other assumptions of the projection study such as immigration and the rate of growth of consumption being endogenous in this study. The optimum solution should be useful therefore, as a check on the structure projected by the Lincoln model for indicative planning. Conversely, the projected structure should be a check on the accuracy and usefulness of the linear programming model, for any wide fluctuations from the projected structure would be unlikely to represent a true optimum situation.

The values of the activities which maximise consumption in 1972/73 are given in Tables IIA to IIC the shadow prices of the restrictions are given in Tables IIA to IIF.

To study the effects of some of the more arbitrary assumptions of the model, some solutions with alternative assumptions were obtained. Firstly, it must be admitted that the figure of \$225 million for autonomous expenditure on housing (the minimum level set for activity P_{33}) was largely a guess, although it was chosen so that the total investment by "Ownership of Property" would be approximately the same as that calculated by the Lincoln model; a solution was therefore calculated with this figure at \$350 million so that some idea of the seriousness of errors of this type to the overall solution might be ascertained. Secondly, the coefficients relating

the target year investment flows to the target year capital stocks have been set at -6.6667 as a linear approximation to a 4.0 to 5.0 per cent annual increase in the levels of investment throughout the planning period; solutions were obtained with these coefficients set at -8.0000 (representing constant levels of investment during the period and indicative of situations when the rate of growth of investment is low) and at -5.5555 (representing about 9.0 per cent annual increases in investment and indicative of situations when it is difficult to achieve high levels of investment early in the planning period). The activity values of these extra solutions are compared with the original solution in Tables IIIA to IIIC and the shadow prices of the restrictions are compared in Tables IIID to IIIF.

Before any comparisons or policy suggestions are made, the properties of the optimum solution warrant some attention.

(a) Optimal Basis

The variables which comprise the optimal basis indicate that the model has behaved much as intended. Very few of the real activities have been excluded from the basis, and those which have (P_{21} , P_{30} , P_{34} , P_{36} , P_{40}) are either not considered to be crucial variables at this level of aggregation, or expected to be omitted due to the choices available.

(b) Shadow Prices of Production Reconciliation Rows

The shadow prices of the production reconciliation rows are in the vicinity of unity, although they are perhaps not as close as one would have hoped.¹ In particular, the shadow prices of "Public Utilities" and "Ownership of Property (interindustry)"

¹ Moustacchi [4] points out that if outputs and inputs are both measured in dollars and the economy is in equilibrium at stable price levels, the shadow prices of the restrictions on current production should be unity.

are greater than 2.0. This would mean that these sectors are "bottlenecks" to economic development and that technological innovation would be of most benefit - at least marginally - if achieved in these areas. Nevertheless, the possibilities that these values are spurious due to anomalies in the parameters should not be ruled out. This applies particularly to "Ownership of Property", which has been handled in a somewhat piecemeal fashion. The high level of government participation in "Public Utilities" could be another contributing factor as such an industry may respond differently to market forces. The shadow prices for "Hunting and Fishing", "Building and Construction", "Transport and Communication", and "Services" are also slightly on the high side, but are not as disturbing. It is worth noting from Table IIID that Solution 4 (constant annual investment) has lower shadow prices for most of the restrictions on current production, although the values for "Public Utilities" and "Ownership of Property" (interindustry) are still rather high.

Constraints R_{14} , R_{15} and R_{17} reconcile the production of activities which are not restricted by a capital stock as other current production activities. Their levels are determined mainly by the level of consumption in the optimal solution. The shadow prices of these restrictions do not have any obvious economic interpretation.

(c) Foreign Exchange, Labour, Savings

Foreign exchange and labour are both limiting resources but savings, as represented here, are not a "bottleneck" to the development of the New Zealand economy. The ratio of savings to consumption chosen was .39 which represents a fairly high level of savings (28 per cent of gross national product). But assuming everything else is unaltered, this ratio can fall by

$399.324 \div 4039.614 = .10$ (i. e. to .29) before the calculated surplus is exhausted. In other words, as long as this coefficient in the model is greater than .29 (representing a ratio of savings to gross national product of only 22 per cent), the linear programming solution will be the same and savings will not be limiting as far as the amount of consumption the model will allow. It seems reasonable to conclude that savings should not be an impediment to economic growth in New Zealand. It is to be remembered, however, that the model has no financial constraints. Although the savings might be theoretically available, the financial mechanisms may not be able to channel them into the most advantageous areas.

In spite of the fairly high shadow price for labour, which supports the oft-voiced notion that New Zealand has a labour shortage, the optimum programme prescribes very little immigration. This supports the warning issued by the Monetary and Economic Council [3] that large scale immigration is not necessarily a solution to the labour shortage problem - especially if due attention is given to the additional strain on housing facilities and various social assets such as hospitals and schools.

Although foreign exchange is limiting, its shadow price is much lower than labour's. This suggests that labour saving technologies should be foremost in the minds of economic strategists.

(d) Shadow Prices of Capital Stock Reconciliation Rows

The shadow prices for the investment restrictions are approximately 16 to 18 per cent. These values might be interpreted as marginal productivities of capital, but the evidence of Table III E (Solutions 3 and 4) shows that little confidence can be attached to these figures: when the annual rate of increase in investment levels is high the marginal

productivity of capital is from 20 to 22 per cent; and when the rate is low the marginal productivity may be as low as 14 per cent. As there are few grounds for choosing one or another rate of growth of investment the true values of these shadow prices must remain open to doubt.

(e) Import Substitution

The consumption activity chosen is that which has five per cent substitution of domestically manufactured final goods for imports. Foreign exchange is sufficiently scarce to warrant some import substitution, but it could not be called a high priority planning consideration. The shadow prices of the excluded consumption activities are extremely small (Table IIC) which means that the level of consumption (and consumption per head) would only be slightly smaller if one of these activities replaced the chosen consumption activity.

TABLE IIA

<u>Optimum Solution (Production Activities)</u>			
	<u>Activity</u>	<u>Level(\$mn)</u>	<u>Shadow Price</u>
P ₁	Farming	1291.964	0.000
P ₂	Forestry	59.352	0.000
P ₃	Forestry Processing	349.875	0.000
P ₄	Hunting & Fishing	9.475	0.000
P ₅	Mining	61.098	0.000
P ₆	Pri. Prod. Proc.	750.052	0.000
P ₇	Other Manufacturing	2338.504	0.000
P ₈	Building & Construction	876.252	0.000
P ₉	Public Utilities	249.542	0.000
P ₁₀	Transport & Communication	683.836	0.000
P ₁₁	Distribution	1195.745	0.000
P ₁₂	Banking & Insurance	217.477	0.000
P ₁₃	Services	620.737	0.000
P ₁₄	Services to Households	32.873	0.000
P ₁₅	Services to Government	357.506	0.000
P ₁₆	Ownership of Property (Interindustry)	92.924	0.000
P ₁₇	Ownership of Property (final demand)	389.072	0.000

TABLE IIB

<u>Optimum Solution (Net Investment Activities)</u>			
	<u>Activity</u>	<u>Level(\$mn.)</u>	<u>Shadow Price</u>
P ₁₈	Farming	57.292	0.000
P ₁₉	Forestry	5.206	0.000
P ₂₀	Forestry Processing	3.750	0.000
P ₂₁	Hunting & Fishing	0.000	1.081
P ₂₂	Mining	2.415	0.000
P ₂₃	Pri. Prod. Proc.	3.828	0.000
P ₂₄	Other Manufacturing	41.315	0.000
P ₂₅	Building & Construction	36.377	0.000
P ₂₆	Public Utilities	66.565	0.000
P ₂₇	Transport & Communication	56.014	0.000
P ₂₈	Distribution	36.026	0.000
P ₂₉	Banking & Insurance	12.929	0.000
P ₃₀	Services	0.000	0.520
P ₃₁	Government (autonomous)	228.000	0.000
P ₃₂	Ownership of Property (interindustry)	32.157	0.000
P ₃₃	Ownership of Property (autonomous)	225.000	0.000

TABLE IIC

Optimum Solution
(Consumption, Immigration, Exporting Activities)

	<u>Activity</u>	<u>Level</u>	<u>Shadow Price</u>
P ₃₄	Consumption (no import substn.)	0.000	0.002
P ₃₅	Consumption (5% import substn.)	4039.614	0.000
P ₃₆	Consumption (10% import substn.)	0.000	0.002
P ₃₇	Farming Exports	383.000	0.000
P ₃₈	Forestry Exports	5.000	0.000
P ₃₉	Forestry Proc. Exports	44.000	0.000
P ₄₀	Hunting & Fishing Exports	0.000	0.278
P ₄₁	Mining Exports	1.000	0.000
P ₄₂	Pri. Prod. Proc. Exports	450.653	0.000
P ₄₃	Other Mfg. Exports	212.000	0.000
P ₄₄	Immigration ('000 people)	18.797	0.000
P ₄₅	Immigrant Consumption	18.797	0.000
P ₄₆	Total Consumption	4058.412	0.000

TABLE IID

Optimal Solution (Shadow Prices of Restrictions)

	<u>Restriction</u>	<u>Shadow Price</u>	<u>Amount in Disposal</u>
R ₁	Farming	1.026	0.000
R ₂	Forestry	1.032	0.000
R ₃	Forestry Proc.	.993	0.000
R ₄	Hunting & Fishing	1.447	0.000
R ₅	Mining	1.121	0.000
R ₆	Pri. Prod. Proc.	1.133	0.000
R ₇	Other Manufacturing	1.025	0.000
R ₈	Building & Construction	1.212	0.000
R ₉	Public Utilities	2.184	0.000
R ₁₀	Transport & Communication	1.330	0.000
R ₁₁	Distribution	.965	0.000
R ₁₂	Banking & Insurance	.932	0.000
R ₁₃	Services	1.388	0.000
R ₁₄	Services to Households	.799	0.000
R ₁₅	Services to Government	.799	0.000
R ₁₆	Ownership of Property(interindustry)	2.221	0.000
R ₁₇	Ownership of Property (final demand)	.484	0.000

TABLE IIE

Optimal Solution (Shadow prices of Restrictions)

	<u>Restriction</u>	<u>Shadow Price</u>	<u>Amount in Disposal</u>
R ₁₈	Farming	0.162	0.000
R ₁₉	Forestry	0.166	0.000
R ₂₀	Forestry Proc.	0.180	0.000
R ₂₁	Hunting & Fishing	0.000	2.720
R ₂₂	Mining	0.169	0.000
R ₂₃	Primary Produce Proc.	0.170	0.000
R ₂₄	Other Manufacturing	0.174	0.000
R ₂₅	Building & Construction	0.163	0.000
R ₂₆	Public Utilities	0.171	0.000
R ₂₇	Transport & Communication	0.170	0.000
R ₂₈	Distribution	0.166	0.000
R ₂₉	Banking & Insurance	0.179	0.000
R ₃₀	Services	0.093	0.000
R ₃₁	Government (autonomous)	1.186	0.000
R ₃₂	Ownership of property	0.181	0.000
R ₃₃	Ownership of property (autonomous)	1.208	0.000

TABLE IIF

Optimal Solution (Shadow Prices of Restrictions)

	<u>Restriction</u>	<u>Shadow Price</u>	<u>Amount in Disposal</u>
R ₃₄	Foreign Exchange	1.141	0.000
R ₃₅	Savings	0.000	399.324
R ₃₆	Labour	2.782	0.000
R ₃₇	Farming Exports	0.097	0.000
R ₃₈	Forestry Exports	0.087	0.000
R ₃₉	Forestry Proc. Exports	0.130	0.000
R ₄₀	Hunting & Fishing Exports	0.000	10.000
R ₄₁	Mining Exports	0.010	0.000
R ₄₂	Primary Produce Proc. Exports	0.000	185.347
R ₄₃	Other Mfg. Exports	0.099	0.000
R ₄₄	Immigrants Consumption	0.931	0.000
R ₄₅	Total Consumption	0.000	0.000

TABLE IIIA

Effect of Changes in Assumptions of Model
(Activity Levels)

Solution No.	1	2	3	4
	Control	Min. P ₃₃ \$350 m.	Capital- Inv. coeff. -5.5555	Capital- Inv. coeff. -8.000
P ₁ Farming	1292	1279	1285	1504
P ₂ Forestry	59	61	59	67
P ₃ Forestry Proc.	350	363	350	402
P ₄ Hunting & Fishing	9	9	9	11
P ₅ Mining	61	64	61	71
P ₆ P. P. P.	750	741	745	967
P ₇ Other Mfg.	2338	2325	2324	2653
P ₈ Bldg & Constr.	876	999	888	1059
P ₉ Public Utilities	250	245	246	282
P ₁₀ Transp. & Comm.	684	684	680	787
P ₁₁ Distribution	1196	1183	1183	1361
P ₁₂ Banking & Insurance	217	214	214	245
P ₁₃ Services	621	610	611	699
P ₁₄ Services to H/hold	33	32	32	36
P ₁₅ Services to Govt.	358	344	351	368
P ₁₆ Ownership(interindustry)	93	92	92	106
P ₁₇ Ownership(final demand)	389	375	380	430

TABLE IIIB

Effect of Changes in Assumptions of Model
(Activity Levels)

Solution No.	1	2	3	4
	Control	Min. P ₃₃ \$350 m.	Capital- Inv. coeff. -5.5555	Capital- Inv. coeff. -8.000
P ₁₈ Farm Investment	57	54	67	87
P ₁₉ Forestry Investment	5	6	6	6
P ₂₀ For. Proc. Inv.	4	4	5	5
P ₂₁ H. & F. Inv.	-	-	-	-
P ₂₂ Mining Inv.	2	3	3	3
P ₂₃ P.P.P. Inv.	4	3	4	15
P ₂₄ Other Mfg. Inv.	41	41	49	48
P ₂₅ Bldg & Constr. Inv.	36	64	47	65
P ₂₆ Public Ut. Inv.	67	62	76	80
P ₂₇ Transp. & Comm. Inv.	56	56	65	78
P ₂₈ Distribution Inv.	36	35	42	45
P ₂₉ Banking & Ins. Inv.	13	12	15	16
P ₃₀ Services Inv.	-	-	-	39
P ₃₁ Govt. Inv. (autonomous)	228	228	228	228
P ₃₂ Ownership Inv.	32	32	30	123
P ₃₃ Ownership Inv. (autonomous)	225	350	225	225

TABLE IIC

Effect of Changes in Assumptions of Model
(Activity Levels)

Solution No.	1	2	3	4
	Control	Min. P ₃₃ \$350 m.	Capital- Inv. coeff. -5.5555	Capital- Inv. coeff. -8.0000
P ₃₄ Cons. (nil)	-	-	-	-
P ₃₅ Cons. (5%)	4040	3889	3961	4155
P ₃₆ Cons. (10%)	-	-	-	-
P ₃₇ Farm. Exports	383	383	383	383
P ₃₈ Forest. Exports	5	5	5	5
P ₃₉ For. Proc. Exports	44	44	44	44
P ₄₀ H. & F. Exports	-	-	-	-
P ₄₁ Mining Exports	1	1	1	1
P ₄₂ P. P. P. Exports	451	452	452	636
P ₄₃ Other Mfg. Exports	212	212	212	212
P ₄₄ Immigrants ('000)	19	21	-	335
P ₄₅ Immigrants Cons.	19	21	-	335
P ₄₆ Total Consumption	4058	3910	3961	4490
Total labour force	1140	1142	1131	1299
Total population	2988	2990	2969	3304
Cons/head (\$)	1358	1308	1334	1359

TABLE IIIID

Effect of Changes in Assumptions of Model
(Shadow Prices)

Solution No.		1	2	3	4
		Control	Min. P ₃₃ \$350m.	Capital- Inv. coeff. -5.5555	Capital- Inv. coeff. -8.0000
R ₁	Farming	1.026	1.026	1.065	.986
R ₂	Forestry	1.032	1.032	1.067	.980
R ₃	Forestry Proc.	.993	.993	1.005	.977
R ₄	Hunting & Fishing	1.447	1.447	1.347	1.453
R ₅	Mining	1.121	1.121	1.155	1.095
R ₆	P. P. P.	1.133	1.133	1.172	1.093
R ₇	Other Mfg.	1.025	1.025	1.021	1.048
R ₈	Bldg. & Constr.	1.212	1.212	1.246	1.179
R ₉	Public Utilities	2.184	2.184	2.513	1.980
R ₁₀	Transp. & Comm.	1.330	1.330	1.393	1.284
R ₁₁	Distribution	.965	.965	.966	.925
R ₁₂	Bank. & Ins.	.932	.932	.998	.871
R ₁₃	Services	1.388	1.388	1.299	1.384
R ₁₄	Services to H/holds	.799	.799	.711	.788
R ₁₅	Services to Govt.	.799	.799	.711	.788
R ₁₆	Ownership(interind.)	2.221	2.221	2.618	1.891
R ₁₇	Ownership(final dem.)	.484	.484	.482	.474

TABLE III

Effect of Changes in Assumptions of Model
(Shadow Prices)

Solution No.	1	2	3	4
	Control	Min. P ₃₃ \$350 m.	Capital- Inv. coeff. -5.5555	Capital- Inv. coeff. -8.0000
R ₁₈ Farm. Cap.	.162	.162	.197	.138
R ₁₉ Forest. Cap.	.166	.166	.202	.141
R ₂₀ For. Proc. Cap.	.180	.180	.219	.154
R ₂₁ H. & F. Cap.	-	-	-	-
R ₂₂ Mining Cap.	.169	.169	.207	.143
R ₂₃ P. P. P. Cap.	.170	.170	.209	.148
R ₂₄ Other Mfg. Cap.	.174	.174	.212	.151
R ₂₅ Bldg & Constr. Cap.	.163	.163	.199	.143
R ₂₆ Publ. Util. Cap.	.171	.171	.209	.147
R ₂₇ Tranp. & Comm. Cap.	.170	.170	.208	.149
R ₂₈ Distribution Cap.	.166	.166	.201	.139
R ₂₉ Bank. & Ins. Cap.	.179	.179	.220	.147
R ₃₀ Services Cap.	.093	.093	-	.146
R ₃₁ Govt. Inv. (autonomous)	1.186	1.186	1.218	1.166
R ₃₂ Ownership Cap.	.181	.181	.223	.148
R ₃₃ Ownership Inv. (auton.)	1.208	1.208	1.237	1.182

TABLE III F

Effect of Changes in Assumptions of Model
(Shadow Prices)

Solution No.	1	2	3	4
	Control	Min. P ₃₃ \$350 m.	Capital- Inv. coeff. -5.5555	Capital- Inv. coeff. -8.0000
R ₃₄ Foreign Exchange	1.141	1.141	1.181	1.351
R ₃₅ Savings	-	-	-	-
R ₃₆ Labour	2.782	2.782	2.475	2.746
R ₃₇ Max. Farm. Exp.	.097	.097	.096	.348
R ₃₈ Max. For. Exp.	.087	.087	.090	.348
R ₃₉ Max. For. Proc. Exp.	.130	.130	.155	.357
R ₄₀ Max. H. & F. Exp.	-	-	-	-
R ₄₁ Max. Mining Exports	.010	.010	.014	.248
R ₄₂ Max. P. P. P. Exports	-	-	-	.251
R ₄₃ Max. Other Mfg. Exp.	.099	.099	.138	.291
R ₄₄ Min. Imm. Cons.	.931	.931	.778	.953
R ₄₅ Total Cons.	.000	.000	.000	.000

(2) Comparison with N. D. C. Projections:

The principal features of the proposed optimum economic structure for 1972/72 are set out in Table IV for comparison with the structure projected by Ross & Philpott (Table V). The comparison should not be over-meticulous as the linear programming model embodies differences of definition and approach which means that it is not simply a maximisation of the structural situation from which Ross and Philpott projected. In particular, this applies to the treatment of exports. In the programming model the contributions of services are treated as margins rather than as actual exports from the servicing sectors. One of the consequences of this has been that the export returns from tourism which appear in the interindustry tables as output from "Transport & Communication" have been allocated to "Other Manufacturing" in Table IV.

This has possibly caused some unfortunate distortion of the results as, although tourist expenditure would contain a large component of "Other Manufacturing", there would also be a considerable element of "Transport and Communication" as well as some "Distribution" and "Services". It is likely that the programmed capital formation pattern is both misleading and over-optimistic as "Transport and Communication" has a much higher capital output ratio than "Other Manufacturing". A more satisfactory way of treating tourism in a programming model would be to have a separate foreign exchange earning activity whose coefficients more closely represented the pattern of visitors' expenditure.

(a) Consumption

A much higher level of consumption is obtained in the linear programming solution than was assumed by Ross and Philpott. The difference is quite marked when considered as consumption per head: \$1,358 per head for the optimisation model compared with \$1,139 per head for the projection model. This suggests that a higher rate of growth can be achieved; although allowance should be made for

imperfect knowledge throughout the economy, immobility within the labour force, the existence of specialised or non-substitutable capital, and the probable inapplicability of the assumed consumption pattern over a wide range of consumption levels; it is likely that the so-called optimum considerably overstates what is actually likely to be achieved.

(b) Output Levels

The levels of output advocated for the productive sectors are similar for both studies except that there is a noticeable switch from "Farming" and "Primary Produce Processing" to "Other Manufacturing" in the linear programming solution. The implication is that manufacturing industries should play an increasingly important role in New Zealand's economic development.

(c) Investment

Investment levels in the programming solution also reflect the need for substitution of "Other Manufacturing" for primary industries. In addition very low levels of investment (particularly net investment) are recommended for "Building and Construction", "Public Utilities", "Transport and Communication" and "Distribution". The programmed investment for these sectors in Solution 4 (Table IIIB) is much closer to the projected investment, so that little importance should be afforded to the absolute levels suggested by the optimum solution. There is noticeably more agreement between the two studies concerning gross investment than net investment - a fact which generates doubts about the treatment of capital replacement, capital stocks and investment generally.

(d) Exports, Imports, Labour

The patterns of exporting and importing differ little between the two studies, but not much scope for differences to

TABLE IV

Economic Structure of N.Z. Economy 1972-73 : Linear Programming Model

	C + G	Exports	Capital Form'n	Total Output	Imports	Investment Net	Gross	Labour
1 Farming	95	351	7	1292	47	57	120	113
2 Forestry	6	4	1	59	2	5	10	9
3 Forestry Proc.	10	41	8	349	22	4	19	26
4 Hunting & Fishing	7	-	-	9	1	-	-	3
5 Mining	10	1	-	61	5	2	10	6
6 PPP	133	418	-	750	14	4	14	32
7 Other Mfg.	1043	195 ¹	228	2338	453	41	104	262
8 Bldg & Constr.	66	-	611	876	40	36	55	94
9 Public Utilities	79	1	-	250	6	67	88	14
10 Transp. & Comm.	172	48 ¹	32	684	37	56	97	97
11 Distribution	719	22	78	1196	25	36	80	166
12 Banking & Ins.	95	5	1	217	5	13	27	9
13 Services	350	7	35	621	33	-	18	178
14 Serv. to H/H.	33	-	-	33	-	-	-	9
15 Serv. to Govt.	358	-	-	358	-	228	228	103
16 Ownership	382	2	-	389	2	257	307	19
Imports					288			
Cons.	288							
Cap.			178		178			
Other	100							
	4058	1095	1177		1155	806	1177	1140

¹ See Note in Appendix III for an explanation of why these values differ markedly from the corresponding values in Table 5.5.

TABLE V

Economic Structure of N. Z. Economy 1972-73 : Lincoln Projection Model

	C + G	Exports	Capital Form'n	Total Output	Imports	Investment (net)	Investment (gross)	Labour
1 Farming	74	351	41	1469	51	89	160	128
2 Forestry	6	4	1	60	2	4	9	9
3 Forestry Proc.	10	41	10	355	21	3	18	26
4 Hunting & Fishing	6	9	-	17	2	2	3	6
5 Mining	11	-	-	62	5	1	9	6
6 PPP	189	590	29	904	16	14	27	38
7 Other Mfg.	898	80	254	2184	404	26	85	245
8 Bldg & Constr.	67	-	670	936	41	68	88	100
9 Public Utilities	66	2	-	228	6	78	98	13
10 Transp. & Comm.	156	124	33	748	38	92	137	106
11 Distribution	566	53	119	1120	22	27	68	156
12 Banking & Ins.	79	13	1	203	4	8	21	27
13 Services	293	16	32	560	28	2	19)	
14 Serv. to H/H.	27	-	-	27	-	-	-)	259
15 Serv. to Govt.	315	-	-	315	-	228	228)	
16 Ownership	355	6	-	451	2	217	265	incl. in banking
Imports Cons.	218				218			
Cap.			176		176			
Other	77	2						
	3414	1291	1364		1033	859	1234	1117

Source : Ross & Philpott [30] , Table V.

reveal themselves has been allowed. The import coefficients and the maximum exporting limits used in the programming model are taken directly from the data and results of the Lincoln projection model. In spite of this the programmed solution exhibits a marked swing away from exports of processed primary products.

Labour use follows a similar pattern in each study, but the transfer of emphasis from primary industries to secondary manufacturing is again apparent.

(e) Capital Formation

The capital formation attributed to each sector is little different. The rather large differences apparent for the "Farming", "Primary Produce Processing" and "Distribution" can be explained by the fact that in Table V changes in stocks are included in capital formation; stock changes have not been considered in the optimisation study.

(3) Summary:

The linear programming model has produced a plausible economic structure which should be useful for national economic planning in New Zealand. Likewise, it seems that the projection techniques used elsewhere should not seriously mislead planning organisations, although there is some evidence that, and given the assumptions used in this model, a shift of resources out of farming into manufacturing industries would be to the long term advantage of New Zealand. However, Tables IIIA to IIIF demonstrate the danger of making definitive statements with respect to the absolute levels of the variables. The major use of the model should be to illustrate the consequences of changes in key parameters, and highlight parameters to which the solution is sensitive so that special efforts can be made to measure these parameters. Solutions 2, 3 and 4 of Tables IIIA

to IIIF constitute an attempt at the latter use, and the comparison has shown that the assumed annual rate of growth of investment is of some importance. The relative levels of the variables for different parameter "settings" will be considered in the next chapter.

B. Discrete Variations of some Parameters

(1) Nature of Variations:

Conventional parametric programming and sensitivity analysis do not constitute a major part of the analysis in this section as the solution is obviously "stable" in the sense that, due to restricted choice of activities, the optimal basis is not likely to alter very much. This would not be the case, of course, if more technological alternatives were included. But the possibility of large fluctuations in the values of the variables in the optimum solution still exists, and an exploration of this aspect ensues.

A list of the types of variations from the original specification follows:

- (i) Variations in the terms of trade for primary products;
- (ii) Variations in the upper limits for exporting activities;
- (iii) Variations in the labour and capital requirements of some of the important sectors;
- (iv) Variations in the basic level of income necessary for immigrants;
- (v) Variations in the housing capital requirements of immigrants.

(2) Terms of Trade:

It is known that fluctuating terms of trade for agricultural exports significantly affect the New Zealand economy. But the short term vagaries of export prices are difficult to predict and this study in no way accounts for such changes. Nevertheless, if reasonable

projections of medium and long term trends in export prices can be obtained, the resultant changes in the guide-lines for indicative planning can be investigated. To illustrate, the optimum structures were computed for a 20 per cent fall, over the planning period, in agricultural export prices and also for a 20 per cent rise in agricultural export prices. This is done by first lowering and then raising the coefficients for activities P_{37} and P_{42} in Row R_{34} . These solutions (Solutions 5 and 6) are compared with the original solution in Tables VIA to VIF.

There are a number of observations to be made from this exercise.

(a) Vital Role of Agriculture

The importance of allocating resources to "Farming" and "Primary Produce Processing" increases as the terms of trade for output from these sectors deteriorates. This is apparent from the current production levels (Table VIA) and the investment levels (Table VIB) programmed for these sectors. Similarly, when the prospects for agricultural export prices are bright, high levels of output and investment are advocated for farming and related industries. The effect on the level of consumption per head of the terms of trade is also quite graphic as can be seen in Table VIC. It seems fair to conclude that overseas prices for agricultural products are important indicators of the potential prosperity of New Zealand but it is important to remember that when these prices are low, expansion of primary production is still the most effective way of facing the crisis.

This conclusions is a little confusing and warrants a caution as to its interpretation, especially in view of results reported a little later when much more expansive assumptions

are made with respect to exports in other sectors.

The programmed levels of activity for agriculture and agricultural exports depends not only on export prices for the relevant products, but on the overall degree of "tightness" of the export earnings situation. If agricultural export prices are high it is to be expected that, when export earnings are limiting the amount of consumption the model will allow, the programmed level of farming activity is high. It is not as obvious that it should do the same when prices are low. A look at the shadow prices is enlightening, however. In solution 5 (Table VIF) the shadow price for farming exports is .097 and for processed primary exports is zero, compared with .385 for forestry exports, .411 for processed forestry exports, and .354 for manufactured exports. Shadow prices reflect marginal revenues of admitting additional units activities to the solution, or the opportunity costs of omitting them. Agricultural products are brought into the solution at high levels, in spite of their low marginal revenues, because the assumptions relating to other exporting activities are restrictive. Later, when export market assumptions are relaxed, the model tends to choose forestry and manufactured exports rather than farming, thus reflecting the higher shadow prices or opportunity costs.

(b) Foreign Exchange and Labour Scarcity

Unlike savings, foreign exchange and labour have been shown to be factors which limit growth in the New Zealand economy. Labour scarcity dominates foreign exchange scarcity as its shadow price is nearly $2\frac{1}{2}$ times greater, but it is manifest from Table VIF that the shadow price of the foreign exchange restriction increases and that of the labour restriction decreases as the terms of trade for primary products declines. The effect on the opportunity costs of the restrictions on the levels of individual exports is also interesting. As expected, they tend to rise as foreign exchange

becomes relatively more scarce - especially for forestry products and manufactured goods. At the same time the shadow prices for exports from "Farming" and from "Primary Produce Processing" do not show signs of increasing: if the long term prospects in agricultural prices are poor, the increase in farming output should continue, but the greatest marginal benefit to the economy will come from the expansion of export outlets in manufacturing and forestry.

(3) Upper Limits on Exporting Activities:

Irrespective of export prices, uncertainty often exists as to the scope or size of future markets for some products. Often the limits are determined politically - the possibility of the United Kingdom joining the European Economic Community being an example that could affect New Zealand's main market for dairy products - and can only be treated in a trial and error fashion in a study such as this. The export limits used for Solution No. 1 correspond to those projected by Ross and Philpott [10] and are therefore in line with the targets used by the National Development Conference (assuming 1964/65 prices).¹ The likely consequences of changes in these limits were investigated by either doubling or halving the limits for the more important export categories - "Farming" exports (mainly wool), "Primary Produce Processing" exports (meat and dairy products, processed vegetables) and "Other Manufacturing" exports. The results are given in Tables VIIA to VIIF (Solutions 7 to 12). It is of course very unlikely that changes in the size of markets would be so large, but such analysis is worthwhile if some features of cause and effect within the economic system are revealed.

¹ Projections for the N.D.C. were actually carried out in 1967/68 prices (see Targets Committee Report [12], p.47).

TABLE VIA

Effect of Changing Terms of Trade Primary Products
(Activity Levels)

<u>Solution No.</u>		5	1	6
	<u>Terms of Trade</u>	<u>0.8</u>	<u>1.0</u>	<u>1.2</u>
P ₁	Farming	1442	1292	1502
P ₂	Forestry	59	59	63
P ₃	Forestry Proc.	350	350	402
P ₄	Hunting & Fishing	11	9	11
P ₅	Mining	61	61	71
P ₆	P. P. P.	913	750	969
P ₇	Other Mfg.	2285	2338	2473
P ₈	Bldg & Constr.	860	876	1098
P ₉	Public Utilities	243	250	280
P ₁₀	Transp. & Comm.	684	684	773
P ₁₁	Distribution	1163	1196	1365
P ₁₂	Banking & Ins.	210	217	244
P ₁₃	Services	595	621	700
P ₁₄	Services to H/hold	31	33	37
P ₁₅	Services to Govt.	337	358	374
P ₁₆	Ownership(interindustry)	91	93	104
P ₁₇	Ownership(final dem.)	365	389	434

TABLE VIB

Effect of Changing Terms of Trade Primary Products
(Activity Levels)

<u>Solution No.</u>	5	1	6
<u>Terms of Trade</u>	<u>.8</u>	<u>1.0</u>	<u>1.2</u>
P ₁₈ Farm Inv.	87	57	104
P ₁₉ Forest. Inv.	5	5	6
P ₂₀ For. Proc. Inv.	4	4	6
P ₂₁ H. & F. Inv.	-	-	-
P ₂₂ Mining Inv.	2	2	4
P ₂₃ P. P. P. Inv.	14	4	18
P ₂₄ Other Mfg. Inv.	39	41	48
P ₂₅ Bldg & Constr. Inv.	33	36	87
P ₂₆ Public Ut. Inv.	60	67	95
P ₂₇ Transp. & Comm. Inv.	56	56	88
P ₂₈ Distribution Inv.	32	36	55
P ₂₉ Bank. & Ins. Inv.	11	13	19
P ₃₀ Services Inv.	-	-	42
P ₃₁ Govt. Inv. (autonomous)	228	228	228
P ₃₂ Ownership Inv.	23	32	136
P ₃₃ Ownership Inv. (autonomous)	225	225	225

TABLE VIC

Effect of Changing Terms of Trade Primary Products
(Activity Levels)

<u>Solution No.</u>	5	1	6
<u>Terms of Trade</u>	<u>.8</u>	<u>1.0</u>	<u>1.2</u>
P ₃₄ Consumption (nil)	-	-	-
P ₃₅ Consumption (5%)	3805	4040	4229
P ₃₆ Consumption (10%)	-	-	-
P ₃₇ Farm. Exports	383	383	383
P ₃₈ Forest. Exports	5	5	-
P ₃₉ For. Proc. Exports	44	44	44
P ₄₀ H. & F. Exports	2	-	-
P ₄₁ Mining Exports	1	1	-
P ₄₂ P.P.P. Exports	632	451	636
P ₄₃ Other Mfg Exports	212	212	-
P ₄₄ Imm. ('000)	-	19	303
P ₄₅ Imm. Cons.	-	19	303
P ₄₆ Total Cons.	3805	4058	4531
Total labour force	1131	1140	1283
Total population	2969	2988	3272
Cons/head	1282	1358	1385

TABLE VID

Effect of Changing Terms of Trade Primary Products
(Shadow Prices)

<u>Solution No.</u>		5	1	6
	<u>Terms of Trade</u>	<u>.8</u>	<u>1.0</u>	<u>1.2</u>
R ₁	Farming	1.020	1.026	1.028
R ₂	Forestry	1.009	1.032	1.040
R ₃	Forestry Proc.	.998	.993	.994
R ₄	Hunting & Fishing	1.446	1.447	1.480
R ₅	Mining	1.126	1.121	1.118
R ₆	P. P. P.	1.126	1.133	1.135
R ₇	Other Mfg.	1.048	1.025	1.015
R ₈	Bldg & Constr.	1.211	1.212	1.211
R ₉	Public Utilities	2.271	2.184	2.146
R ₁₀	Transp. & Comm.	1.341	1.330	1.324
R ₁₁	Distribution	.921	.965	.982
R ₁₂	Bank. & Ins.	.924	.932	.935
R ₁₃	Services	1.283	1.388	1.439
R ₁₄	Serv. to H/hold.	.705	.799	.836
R ₁₅	Serv. to Govt.	.705	.799	.836
R ₁₆	Ownership(interind.)	2.210	2.221	2.225
R ₁₇	Ownership(final dem.)	.472	.484	.488

TABLE VI

Effect of Changing Terms of Trade Primary Products
(Shadow Prices)

<u>Solution No.</u>	5	1	6
<u>Terms of Trade</u>	<u>.8</u>	<u>1.0</u>	<u>1.2</u>
R ₁₈ Farm. Cap.	.169	.162	.159
R ₁₉ Forest. Cap.	.173	.166	.163
R ₂₀ For. Proc. Cap.	.188	.180	.178
R ₂₁ H. & F. Cap.	.044	-	-
R ₂₂ Mining Cap.	.175	.169	.167
R ₂₃ P.P.P. Cap.	.182	.170	.166
R ₂₄ Other Mfg Cap.	.184	.174	.170
R ₂₅ Bldg & Constr. Cap.	.175	.163	.157
R ₂₆ Publ. Util. Cap.	.181	.171	.167
R ₂₇ Transp. & Comm. Cap.	.184	.170	.164
R ₂₈ Distribution Cap.	.168	.166	.165
R ₂₉ Bank. & Ins. Cap.	.181	.179	.178
R ₃₀ Services Cap.	-	.093	.167
R ₃₁ Govt. Inv. (autonomous)	1.197	1.186	1.180
R ₃₂ Ownership Cap.	.181	.181	.181
R ₃₃ Ownership Inv. (autonomous)	1.208	1.208	1.207

TABLE VIF

Effect of Changing Terms of Trade Primary Products
(Shadow Prices)

<u>Solution No.</u>	5	1	6
<u>Terms of Trade</u>	<u>0.8</u>	<u>1.0</u>	<u>1.2</u>
R ₃₄ Foreign Exchange	1.417	1.141	1.026
R ₃₅ Savings	-	-	-
R ₃₆ Labour	2.456	2.782	2.912
R ₃₇ Max. Farm Exp.	.097	.097	.186
R ₃₈ Max. For. Exp.	.385	.087	-
R ₃₉ Max. For. Proc. Exp.	.411	.130	.014
R ₄₀ Max. H. & F. Exp.	-	-	-
R ₄₁ Max. Mining Exp.	.283	.010	-
R ₄₂ Max. P. P. P. Exp.	-	-	.088
R ₄₃ Max. Other Mfg. Exp.	.354	.099	-
R ₄₄ Min. Imm. Cons.	.854	.931	.927
R ₄₅ Total Cons.	-	-	-

(a) All Export Limits Doubled

When exports are "unchained" as for Solution 7 there is a distinct movement away from primary exports - especially processed primary exports. The level of output for "Primary Produce Processing" is very small, the levels of investment for "Farming" and "Primary Produce Processing" are also low, and the level of processed primary exports is programmed to be zero (Tables VIIA, VIIB, VIIC). Processed forestry exports and secondary manufactured exports are the only exporting activities which enter the solution at the maximum level (Table VIIF). The shadow price for labour is rather high, but the solution does not recommend a large amount of immigration.

(b) Some Export Limits Doubled

Solutions 8 and 9 show the effects of doubling the maximum limits for "Farming" exports and "Other Manufacturing" exports respectively.¹ These solutions are very similar (they have exactly the same dual solution - i. e. the optimal bases have the same composition). The only real difference is the expected one : Solution 8 has high levels of output and investment in "Farming" whereas Solution 9 has high levels of output and investment in "Other Manufacturing". It is interesting to note that Solution 9 (representative of rapidly expanding markets for manufactured goods) has a much higher level (although still very low) of output and exporting of processed primary products than Solution 8. This suggests that there is something of a complementary effect between "Other Manufacturing" and "Primary Produce Processing". However, it should be remembered that in Solution 9

¹ In Solution 1, processed primary exports do not enter at the maximum level so there was no point in increasing this limit.

TABLE VIIA Effect of Varying Export Limits (Activity Levels)

<u>Solution No.</u>	1	7	8	9	10	11	12
<u>Max. exports</u>	<u>Control</u>	<u>All x 2</u>	<u>Farming x 2</u>	<u>Mfg x 2</u>	<u>Farming x $\frac{1}{2}$</u>	<u>PPP x $\frac{1}{2}$</u>	<u>Mfg x $\frac{1}{2}$</u>
P ₁ Farming	1292	1181	1417	1139	1223	1145	1361
P ₂ Forestry	59	60	59	59	59	55	60
P ₃ Forestry Proc.	350	398	347	348	352	321	351
P ₄ Hunt. & Fishing	9	9	9	9	9	17	9
P ₅ Mining	61	59	59	60	62	56	61
P ₆ P.P.P.	750	306	379	565	928	598	834
P ₇ Other Mfg.	2338	2535	2360	2526	2343	2160	2259
P ₈ Bldg & Constr.	876	876	880	872	878	800	879
P ₉ Public Utilities	250	248	248	249	250	230	250
P ₁₀ Transp. & Comm.	684	683	681	683	685	622	684
P ₁₁ Distribution	1196	1194	1207	1191	1191	1094	1197
P ₁₂ Bank. & Ins.	217	218	218	218	217	201	217
P ₁₃ Services	621	627	624	624	618	574	619
P ₁₄ Serv. to H/hold.	33	33	33	33	33	31	33
P ₁₅ Serv. to Govt.	358	359	359	359	356	335	356
P ₁₆ Ownership(interind.)	93	94	93	94	93	85	92
P ₁₇ Ownership(final dem.)	389	391	390	390	387	363	388

TABLE VIIB

Effect of Varying Export Limits (Activity Levels)

<u>Solution No.</u>	1	7	8	9	10	11	12
<u>Max. exports</u>	Control	All x 2	Farming x 2	Mfg x 2	Farming x $\frac{1}{2}$	PPP x $\frac{1}{2}$	Mfg x $\frac{1}{2}$
P ₁₈ Farm Inv.	57	32	85	23	42	24	71
P ₁₉ Forest. Inv.	5	6	5	5	5	4	5
P ₂₀ For. Proc. Inv.	4	6	3	4	4	2	4
P ₂₁ H. & F. Inv.	-	-	-	-	-	2	-
P ₂₂ Mining Inv.	2	2	2	2	3	2	2
P ₂₃ P. P. P. Inv.	4	-	-	-	15	-	9
P ₂₄ Other Mfg. Inv.	41	52	42	51	42	32	37
P ₂₅ Bldg. & Const. Inv.	36	36	37	35	37	19	37
P ₂₆ Publ. Ut. Inv.	67	65	65	66	67	48	67
P ₂₇ Transp. & Comm. Inv.	56	56	55	56	56	34	53
P ₂₈ Distribution Inv.	36	36	37	35	35	25	36
P ₂₉ Bank. & Ins. Inv.	13	13	13	13	13	9	13
P ₃₀ Services Inv.	-	-	-	-	-	-	-
P ₃₁ Govt. Inv. (autonomous)	228	228	228	228	228	228	228
P ₃₂ Ownership Inv.	32	34	32	33	32	16	32
P ₃₃ Ownership Inv. (autonomous)	225	225	225	225	225	225	225

TABLE VIII

Effect of Varying Export Limits (Activity Levels)

<u>Solution No.</u>	<u>Max. exports</u>	<u>Control</u>	<u>All. x 2</u>	<u>Farming x 2</u>	<u>Mfg x 2</u>	<u>Farming x 2</u>	<u>PPP x $\frac{1}{2}$</u>	<u>Mfg x $\frac{1}{2}$</u>
P ₃₄	Cons. (nil)	-	-	-	-	-	-	-
P ₃₅	Cons. (5%)	4040	4060	4054	4051	-	-	-
P ₃₆	Cons. (10%)	-	-	-	-	4018	3785	4026
P ₃₇	Farm. Exports	383	612	766	383	192	383	383
P ₃₈	Forest. Exports	5	-	5	5	5	5	5
P ₃₉	For. Proc. Exports	44	88	44	44	44	44	44
P ₄₀	H. & F. Exports	-	-	-	-	-	10	-
P ₄₁	Mining Exports	1	-	-	-	1	1	1
P ₄₂	P. P. P. Exports	451	-	74	262	632	318	537
P ₄₃	Other Mfg Exports	212	424	212	424	212	212	106
P ₄₄	Imm. ('000)	19	17	18	18	19	-	19
P ₄₅	Imm. Cons.	19	17	18	18	19	-	19
P ₄₆	Total Cons.	4058	4077	4072	4069	4038	3785	4046
	Total Labour Force	1140	1139	1140	1140	1140	1131	1140
	Total Population	2988	2986	2987	2987	2988	2969	2988
	Cons. /head (\$)	1358	1365	1363	1363	1351	1275	1354

TABLE VIII

Effect of Varying Export Limits (Shadow Prices)

<u>Solution No.</u>		1	7	8	9	10	11	12
<u>Max. exports</u>		<u>Control</u>	<u>All x 2</u>	<u>Farming x 2</u>	<u>Mfg x 2</u>	<u>Farming x 2</u>	<u>PPP x $\frac{1}{2}$</u>	<u>Mfg x $\frac{1}{2}$</u>
R ₁	Farming	1.026	1.032	1.032	1.032	1.025	.970	1.025
R ₂	Forestry	1.032	1.044	1.042	1.042	1.031	.834	1.031
R ₃	Forestry Proc.	.993	.998	.998	.998	.992	.955	.992
R ₄	Hunting & Fishing	1.447	1.482	1.472	1.472	1.446	1.139	1.446
R ₅	Mining	1.121	1.124	1.124	1.124	1.120	1.161	1.120
R ₆	P. P. P.	1.133	1.064	1.063	1.063	1.132	.949	1.132
R ₇	Other Mfg.	1.025	1.021	1.023	1.023	1.024	1.218	1.024
R ₈	Bldg. & Constr.	1.212	1.217	1.217	1.217	1.211	1.202	1.211
R ₉	Publ. Utilities	2.184	2.162	2.171	2.171	2.182	2.916	2.182
R ₁₀	Transp. & Comm.	1.330	1.331	1.332	1.332	1.329	1.422	1.329
R ₁₁	Distribution	.965	.984	.980	.980	.964	.604	.964
R ₁₂	Bank. & Ins.	.932	.939	.938	.938	.931	.875	.931
R ₁₃	Services	1.388	1.437	1.425	1.425	1.388	.663	1.388
R ₁₄	Serv. to H/hold.	.799	.834	.826	.826	.798	-	.798
R ₁₅	Serv. to Govt.	.799	.834	.826	.826	.798	-	.798
R ₁₆	Ownership(interind.)	2.221	2.235	2.234	2.234	2.220	2.131	2.220
R ₁₇	Ownership(final dem.)	.484	.490	.489	.489	.483	.387	.483

TABLE VIII

Effect of Varying Export Limits (Shadow Prices)

<u>Solution No.</u>		1	7	8	9	10	11	12
<u>Max. exports</u>		<u>Control</u>	<u>All x 2</u>	<u>Farming x 2</u>	<u>Mfg x 2</u>	<u>Farming x 2</u>	<u>PPP x $\frac{1}{2}$</u>	<u>Mfg x $\frac{1}{2}$</u>
R ₁₈	Farm. Cap.	.162	.160	.161	.161	.162	.221	.162
R ₁₉	Forest. Cap.	.166	.164	.165	.165	.166	.225	.166
R ₂₀	For. Proc. Cap.	.180	.178	.179	.179	.180	.252	.180
R ₂₁	H. & F. Cap.	-	-	-	-	-	.215	-
R ₂₂	Mining Cap.	.169	.168	.168	.168	.169	.217	.169
R ₂₃	P. P. P. Cap.	.170	-	-	-	.170	-	.170
R ₂₄	Other Mfg. Cap.	.174	.171	.172	.172	.174	.262	.174
R ₂₅	Bldg. & Constr. Cap.	.163	.159	.160	.160	.163	.273	.163
R ₂₆	Publ. Util. Cap.	.171	.168	.169	.169	.171	.258	.171
R ₂₇	Transp. & Comm. Cap.	.170	.166	.167	.167	.170	.287	.170
R ₂₈	Distribution Cap.	.166	.166	.166	.166	.166	.185	.166
R ₂₉	Bank. & Ins. Cap.	.179	.179	.179	.179	.179	.194	.179
R ₃₀	Services Cap.	.093	.161	.144	.144	.093	-	.093
R ₃₁	Govt. Inv. (autonomous)	1.186	1.187	1.188	1.188	1.185	1.277	1.185
R ₃₂	Ownership Cap.	.181	.182	.182	.182	.181	.182	.181
R ₃₃	Ownership Inv. (autonomous)	1.208	1.213	1.213	1.213	1.207	1.213	1.207

TABLE VIIF

Effect of Varying Export Limits (Shadow Prices)

<u>Solution No.</u>		1	7	8	9	10	11	12
<u>Max. exports</u>		<u>Control</u>	<u>All x 2</u>	<u>Farming x 2</u>	<u>Mfg x 2</u>	<u>Farming x 2</u>	<u>PPP x $\frac{1}{2}$</u>	<u>Mfg x $\frac{1}{2}$</u>
R ₃₄	Foreign Exch.	1.141	1.050	1.077	1.077	1.141	3.462	1.141
R ₃₅	Savings	-	-	-	-	-	-	-
R ₃₆	Labour	2.782	2.905	2.876	2.876	2.780	-*	2.780
R ₃₇	Max. Farm. Exp.	.097	-	.027	.027	.097	2.477	.097
R ₃₈	Max. For. Exp.	.087	-	.013	.013	.087	2.595	.087
R ₃₉	Max. For. Proc. Exp.	.130	.033	.060	.060	.130	2.493	.130
R ₄₀	Max. H. & F. Exp.	-	-	-	-	-	2.320	-
R ₄₁	Max. Mining Exp.	.010	-	-	-	.010	2.301	.010
R ₄₂	Max. P. P. P. Exp.	-	-	-	-	-	2.498	-
R ₄₃	Max. Oth. Mfg. Exp.	.098	.011	.035	.035	.098	2.249	.098
R ₄₄	Min. Imm. Cons.	.931	.927	.928	.928	.930	1.017	.930
R ₄₅	Total Cons.	-	-	-	-	-	-	-

* 85.3 thousand labour units (man-years) in disposal.

"Farming" exports are restricted whereas in Solution 8 they are not. The higher level of "Primary Produce Processing" is more likely a substitution effect to replace the export income lost by restricting "Farming" exports.

(c) Some Export Limits Halved

As the outlook for New Zealand's markets has recently been more pessimistic than optimistic, optimal solutions with half the export potential for "Farming", "Primary Produce Processing", and "Other Manufacturing" were obtained; these are Solutions 10, 11 and 12.

The already observed substitution between "Farming", "Primary Produce Processing" and "Other Manufacturing" is again apparent. The phenomenon of complementarity between "Primary Produce Processing" and "Other Manufacturing" is also discernible from Solutions 11 and 12; in fact, the levels of output and investment for "Other Manufacturing" are lower when "Primary Produce Processing" exports are restricted than when "Other Manufacturing" exports are restricted. In all three of these solutions the consumption activity with the greatest amount of import substitution is chosen.

However, the most striking feature of the comparison is the severity with which restriction of exports of processed primary products affects the economy (Solution 11). Apart from the substitution effect mentioned earlier, the relative importance of each sector is similar to other solutions, but the absolute levels of output and investment are pared down to the extent that labour is no longer a scarce resource. In fact there are 85,300 surplus labour units (man years) in the optimum solution. The shadow prices of foreign exchange and each of the restrictions on export levels are very high (Table VIIF) and consumption per head is very low (Table VIIC). It is noticeable in Table VIIC, in fact, that

although there are differences in the economic structure, consumption per head is practically unaltered for all solutions except Solution 11. For Solution 11 it is 7 per cent below the solution with the highest consumption per head (Solution 7). Consumption per head for Solution 10, the second lowest, is only 1 per cent below that for Solution 7. The implication is that New Zealand's economic prosperity (measured by the level of employment and consumption per head) is extremely dependent on the maintenance of markets for processed primary products. This is somewhat disturbing as dairy products constitute a major portion of these exports and the markets for these are anything but secure. At the same time, the results of Solutions 7, 8 and 9 should not be forgotten; that these products do not play an important role if all other markets are expanding. Also, processed primary products include meat for which markets appear favourable. It would be helpful if the analysis could be repeated with a disaggregated "Primary Produce Processing" sector.¹

It seems reasonable to conclude that serious efforts should be made to maintain the dairy market - at least in the short term. However, evidence also exists that expansion of other markets (processed forestry products and manufactured goods in particular) could be a more positive approach to economic policy.

(4) Technological Change:

The measurement of technological change is currently one of the most urgent needs of economic science. Technology can be thought of as a "way of using" capital, labour or any other primary resource. If the same input of capital or labour, ceteris paribus,

¹ This will soon be possible due to the disaggregation of the Lincoln model by Professor B.J. Ross.

can be used so that greater output is achieved, a technological change has occurred. The present model has taken some account of this by assuming a reduction in the labour-output ratios during the planning period. As a possible guide to the allocation of research expenditure both the capital-output and labour-output ratios were reduced for "Farming", "Processed Primary Products" and "Other Manufacturing" in turn. It was hoped that the relative impact of technology on these sectors would indicate in which sectors technological change would be of most benefit to the economy as a whole. Solutions 13, 14 and 15 are set out in Tables VIIIA to VIIF, and some comments on them follow.

The results are only meaningful, however, if the relative research effort required to produce 10 per cent technical change in each sector is taken into account. For instance, manufacturing in New Zealand is much more diverse than agriculture and the results of individual research efforts in industrial science will not usually have widespread relevance. The cost of advancing technology by 10 per cent in the whole manufacturing sector is therefore likely to be greater than for agriculture. Conceptually, the problem of allocating research funds could be handled in a model such as this, but enormous operational problems - such as the availability of the appropriate cost data, knowledge of the time lags between research findings and increases in productivity, and even the difficulty in assessing which sciences are relevant to which industries - make this a practical impossibility at the moment. Nevertheless, with this shortcoming in mind, the results of altering some capital-output ratios follow.

Firstly, in terms of consumption per head, technological change is of most benefit when achieved in the "Other Manufacturing" sector, but it is only slightly less beneficial when achieved in "Farming" (Table VIIC).

TABLE VIIIA

Possible Effects of Technological Change
(Activity Levels)

<u>Solution No.</u>	1	13	14	15
<u>10% Tech. Change</u>	<u>Control</u>	<u>Farming</u>	<u>PPP</u>	<u>Other Mfg.</u>
P ₁ Farming	1292	1304	1296	1325
P ₂ Forestry	59	60	59	60
P ₃ Forestry Proc.	350	351	351	357
P ₄ Hunting & Fishing	9	10	10	10
P ₅ Mining	61	61	60	62
P ₆ P. P. P.	750	763	754	783
P ₇ Other Mfg.	2338	2354	2344	2389
P ₈ Bldg & Constr.	876	879	877	889
P ₉ Public Utilities	250	252	250	255
P ₁₀ Transp. & Comm.	684	689	685	700
P ₁₁ Distribution	1196	1206	1199	1223
P ₁₂ Bank. & Ins.	217	220	218	222
P ₁₃ Services	621	629	623	633
P ₁₄ Serv. to H/hold.	33	33	33	34
P ₁₅ Serv. to Govt.	358	363	359	365
P ₁₆ Ownership(interind.)	93	94	93	95
P ₁₇ Ownership(final dem.)	389	395	390	397

TABLE VIII B

Possible Effects of Technological Change
(Activity Levels)

<u>Solution No.</u>	1	13	14	15
<u>10% Tech. Change</u>	<u>None</u>	<u>Farming</u>	<u>PPP</u>	<u>Mfg.</u>
P ₁₈ Farm Inv.	57	31	58	65
P ₁₉ Forest. Inv.	5	5	5	6
P ₂₀ For. Proc. Inv.	4	4	4	4
P ₂₁ H. & F. Inv.	-	-	-	-
P ₂₂ Mining Inv.	2	2	2	3
P ₂₃ P. P. P. Inv.	4	5	-	6
P ₂₄ Other Mfg. Inv.	41	42	42	31
P ₂₅ Bldg. & Const. Inv.	36	36	36	39
P ₂₆ Publ. Ut. Inv.	67	69	67	72
P ₂₇ Trans. & Comm. Inv.	56	58	57	62
P ₂₈ Distribution Inv.	36	37	36	39
P ₂₉ Bank. & Ins. Inv.	13	13	13	14
P ₃₀ Services Inv.	-	-	-	-
P ₃₁ Govt. Inv. (autonomous)	228	228	228	228
P ₃₂ Ownership Inv.	32	33	32	34
P ₃₃ Ownership Inv. (autonomous)	225	225	225	225

TABLE VIII C

Possible Effects of Technological Change
(Activity Levels)

<u>Solution No.</u>		1	13	14	15
<u>10% Tech. Change</u>		<u>None</u>	<u>Farming</u>	<u>PPP</u>	<u>Mfg</u>
P ₃₄	Cons. (nil)	-	-	-	-
P ₃₅	Cons. (5%)	4040	4103	4053	4129
P ₃₆	Cons. (10%)	-	-	-	-
P ₃₇	Farm. Exports	383	383	383	383
P ₃₈	Forest. Exports	5	5	5	5
P ₃₉	For. Proc. Exports	44	44	44	44
P ₄₀	H. & F. Exports	-	-	-	-
P ₄₁	Mining Exports	1	-	-	1
P ₄₂	P. P. P. Exports	451	459	454	477
P ₄₃	Other Mfg. Exports	212	212	212	212
P ₄₄	Imm. ('000)	19	17	18	16
P ₄₅	Imm. Cons.	19	17	18	16
P ₄₆	Total Cons.	4058	4120	4071	4144
	Total labour force	1140	1139	1140	1139
	Total population	2988	2986	2987	2985
	Cons/head (\$)	1358	1380	1363	1388

TABLE VIIIID

Possible Effects of Technological Change
(Shadow Prices)

<u>Solution No.</u>		1	13	14	15
<u>10% Tech. Change</u>		<u>None</u>	<u>Farming</u>	<u>PPP</u>	<u>Mfg</u>
R ₁	Farming	1.026	.969	1.033	1.029
R ₂	Forestry	1.032	1.040	1.043	1.041
R ₃	Forestry Proc.	.993	.998	.999	1.002
R ₄	Hunting & Fishing	1.447	1.446	1.479	1.471
R ₅	Mining	1.121	1.125	1.125	1.128
R ₆	P. P. P.	1.133	1.094	1.051	1.138
R ₇	Other Mfg.	1.025	1.024	1.023	.994
R ₈	Bldg & Constr.	1.212	1.217	1.218	1.216
R ₉	Public Utilities	2.184	2.180	2.169	2.185
R ₁₀	Transp. & Comm.	1.330	1.334	1.333	1.337
R ₁₁	Distribution	.965	.975	.982	.975
R ₁₂	Bank. & Ins.	.932	.937	.939	.938
R ₁₃	Services	1.388	1.412	1.432	1.419
R ₁₄	Serv. to H/hold	.799	.817	.830	.819
R ₁₅	Serv. to Govt.	.799	.817	.830	.819
R ₁₆	Ownership(interind.)	2.221	2.233	2.236	2.231
R ₁₇	Ownership(final dem.)	.484	.488	.490	.487

TABLE VIII

Possible Effects of Technological Change
(Shadow Prices)

<u>Solution No.</u>	1	13	14	15
<u>10% Tech. Change</u>	<u>None</u>	<u>Farming</u>	<u>PPP</u>	<u>Mfg</u>
R ₁₈ Farm. Cap.	.162	.161	.160	.160
R ₁₉ Forest. Cap.	.166	.165	.164	.165
R ₂₀ For. Proc. Cap.	.180	.180	.179	.181
R ₂₁ H. & F. Cap.	-	-	-	-
R ₂₂ Mining Cap.	.169	.169	.168	.169
R ₂₃ P. P. P. Cap.	.170	.169	-	.170
R ₂₄ Other Mfg. Cap.	.174	.173	.172	.174
R ₂₅ Bldg. & Constr. Cap.	.163	.162	.160	.162
R ₂₆ Publ. Util. Cap.	.171	.170	.169	.171
R ₂₇ Trans. & Comm. Cap.	.170	.168	.167	.169
R ₂₈ Distribution Cap.	.166	.166	.166	.165
R ₂₉ Bank. & Ins. Cap.	.179	.179	.179	.179
R ₃₀ Services Cap.	.093	.127	.153	.131
R ₃₁ Govt. Inv. (autonomous)	1.186	1.189	1.189	1.189
R ₃₂ Ownership Cap.	.181	.182	.182	.182
R ₃₃ Ownership Inv. (autonomous)	1.208	1.213	1.214	1.212

TABLE VIII F

Possible Effects of Technological Change
(Shadow Prices)

<u>Solution No.</u>	1	13	14	15
<u>10% Tech. Change</u>	<u>None</u>	<u>Farming</u>	<u>PPP</u>	<u>Mfg.</u>
R ₃₄ Foreign Exchange	1.141	1.105	1.066	1.147
R ₃₅ Savings	-	-	-	-
R ₃₆ Labour	2.782	2.845	2.891	2.853
R ₃₇ Max. Farm Exp.	.097	.113	.015	.099
R ₃₈ Max. For. Exp.	.087	.043	-	.083
R ₃₉ Max. For. Proc. Exp.	.130	.089	.048	.125
R ₄₀ Max. H. & F. Exp.	-	-	-	-
R ₄₁ Max. Mining Exp.	.010	-	-	.009
R ₄₂ Max. P. P. P. Exp.	-	-	-	-
R ₄₃ Max. Oth. Mfg. Exp.	.099	.063	.024	.132
R ₄₄ Min. Imm. Cons.	.931	.929	.928	.929
R ₄₅ Total Cons.	.000	.000	.000	.000

The effects on output levels seem to differ little (Table VIIIA). The most noticeable differences are in the programmed investment levels (Table VIIIB): the level of investment to maintain production does not need to be as high for the sector in which the technological change has taken place. This may not be of major importance as total investment is restricted only by foreign exchange - not by the availability of savings. Nevertheless, it could take some strain off the mechanisms for financing investment, a possible bottleneck which is not accounted for in the model.

Thirdly, the shadow prices for foreign exchange and labour (Table VIIIF) indicate that technological change tends to amplify the labour shortage problem. For the "Farming" and "Other Manufacturing" sectors the shadow prices of the restrictions on export levels fall (although only slightly when the technological change is in the "Other Manufacturing" sector) except for the sector in which the technological change has occurred. This could mean that policies which encourage technological change in these sectors will be of limited use unless simultaneously matched by policies to expand export markets for the same sectors.

(5) Consumption for Immigrants

The consumption activity for immigrants has been mooted as an approximation to optimising consumption per head. As a means of evaluating the effectiveness of the ploy, a number of solutions were obtained in which the consumption requirements of a unit of immigration (1000 people) was reduced. These are Solutions 16 to 19 set out in Tables IXA to IXF.

As soon as the coefficient is reduced from 1.0 to 0.9 the levels of output and investment rise considerably (Tables IXA and IXB), but thereafter they change very little. Total consumption rises only slightly and the level of immigration steadily increases.

TABLE IXA

Effect of Lowering Immigrants' Consumption Requirements
(Activity Levels)

<u>Solution No.</u>	1	16	17	18	19
<u>Min. cons. (\$mn/'000)</u>	<u>1.0</u>	<u>0.9</u>	<u>0.8</u>	<u>0.5</u>	<u>0.0</u>
P ₁ Farming	1292	1490	1490	1492	1492
P ₂ Forestry	59	68	68	68	68
P ₃ Forestry Proc.	350	407	407	410	411
P ₄ Hunt. & Fish.	9	10	10	19	19
P ₅ Mining	61	72	72	72	72
P ₆ P. P. P.	750	956	956	957	957
P ₇ Other Mfg.	2338	2657	2657	2674	2675
P ₈ Bldg. & Constr.	876	1101	1102	1117	1121
P ₉ Pub. Ut.	250	276	276	277	277
P ₁₀ Transp. & Comm.	684	784	784	789	790
P ₁₁ Distribution	1196	1345	1345	1352	1352
P ₁₂ Bank. & Ins.	217	240	240	241	241
P ₁₃ Services	621	685	685	688	688
P ₁₄ Serv. to H/hold.	33	35	35	35	35
P ₁₅ Serv. to Govt.	358	358	361	369	383
P ₁₆ Ownership(interind.)	93	105	105	105	105
P ₁₇ Ownership(final dem.)	389	415	415	416	416

TABLE IXB

Effect of Lowering Immigrants' Consumption Requirements
(Activity Levels)

<u>Solution No.</u>	1	16	17	18	19
<u>Min. cons. (\$mn/'000)</u>	<u>1.0</u>	<u>0.9</u>	<u>0.8</u>	<u>0.5</u>	<u>0.0</u>
P ₁₈ Farm. Inv.	57	102	102	102	102
P ₁₉ Forest. Inv.	5	8	8	8	8
P ₂₀ For. Proc. Inv.	4	7	7	7	7
P ₂₁ H. & F. Inv.	-	-	-	2	2
P ₂₂ Mining Inv.	2	4	4	4	4
P ₂₃ P. P. P. Inv.	4	17	17	17	17
P ₂₄ Other Mfg Inv.	41	58	58	59	59
P ₂₅ Bldg. & Const. Inv.	36	88	88	91	92
P ₂₆ Publ. Ut. Inv.	67	91	91	92	92
P ₂₇ Trans. & Comm. Inv.	56	92	92	94	94
P ₂₈ Distribution Inv.	36	53	53	54	54
P ₂₉ Bank. & Ins. Inv.	13	18	18	18	18
P ₃₀ Services Inv.	-	44	44	48	49
P ₃₁ Govt. Inv. (autonomous)	228	228	228	228	228
P ₃₂ Ownership Inv.	32	141	142	151	154
P ₃₃ Ownership Inv. (autonomous)	225	225	225	225	225

TABLE IXC

Effect of Lowering Immigrants' Consumption Requirements
(Activity Levels)

<u>Solution No.</u>	1	16	17	18	19
<u>Min. cons. (\$mn/'000)</u>	<u>1.0</u>	<u>0.9</u>	<u>0.8</u>	<u>0.5</u>	<u>0.0</u>
P ₃₄ Cons. (nil)	-	-	-	-	-
P ₃₅ Cons. (5%)	4040	-	-	-	-
P ₃₆ Cons. (10%)	-	4044	4074	4168	4338
P ₃₇ Farm. Exports	383	383	383	383	383
P ₃₈ Forest. Exports	5	5	5	5	5
P ₃₉ For. Proc. Exports	44	44	44	44	44
P ₄₀ H. & F. Exports	-	-	-	10	10
P ₄₁ Mining Exports	1	1	1	1	1
P ₄₂ P. P. P. Exports	451	636	636	636	636
P ₄₃ Other Mfg. Exports	212	212	212	212	212
P ₄₄ Imm. ('000)	19	320	322	346	357
P ₄₅ Imm. Cons.	19	288	257	173	-
P ₄₆ Total Cons.	4058	4331	4331	4341	4338
Total labour force	1140	1291	1292	1304	1310
Total Population	2988	3289	3291	3315	3326
Cons. /head (\$)	1358	1317	1316	1310	1304

TABLE IXD

Effect of Lowering Immigrants' Consumption Requirements
(Shadow Prices)

<u>Solution No.</u>	1	16	17	18	19
<u>Min. cons. (\$mn/'000)</u>	<u>1.0</u>	<u>0.9</u>	<u>0.8</u>	<u>0.5</u>	<u>0.0</u>
R ₁ Farming	1.026	1.023	1.019	1.006	.984
R ₂ Forestry	1.032	1.027	1.014	.975	.907
R ₃ Forestry Proc.	.993	.990	.987	.978	.962
R ₄ Hunt. & Fish.	1.447	1.434	1.389	1.591	1.382
R ₅ Mining	1.121	1.118	1.120	1.125	1.134
R ₆ P. P. P.	1.133	1.129	1.125	1.111	1.086
R ₇ Other mfg.	1.025	1.025	1.036	1.069	1.129
R ₈ Bldg. & Const.	1.212	1.208	1.207	1.202	1.195
R ₉ Publ. Ut.	2.184	2.186	2.230	2.360	2.591
R ₁₀ Transp. & Comm.	1.330	1.327	1.332	1.346	1.371
R ₁₁ Distribution	.965	.959	.937	.868	.749
R ₁₂ Bank. & Ins.	.932	.930	.927	.914	.894
R ₁₃ Services	1.388	1.396	1.354	1.224	.997
R ₁₄ Serv. to H/hold	.799	.787	.738	.587	.324
R ₁₅ Serv. to Govt.	.799	.787	.738	.587	.324
R ₁₆ Ownership(interind.)	2.221	2.216	2.209	2.187	2.152
R ₁₇ Ownership(final dem.)	.484	.482	.476	.475	.424

TABLE IXE

Effect of Lowering Immigrants' Consumption Requirements
(Shadow Prices)

<u>Solution No.</u>	1	16	17	18	19
<u>Min. cons. (\$mn/'000)</u>	<u>1.0</u>	<u>0.9</u>	<u>0.8</u>	<u>0.5</u>	<u>0.0</u>
R ₁₈ Farm. Cap.	.162	.162	.166	.176	.195
R ₁₉ Forest Cap.	.166	.166	.169	.180	.199
R ₂₀ Forest Proc. Cap.	.180	.181	.185	.198	.221
R ₂₁ H. & F. Cap.	-	-	-	.175	.192
R ₂₂ Mining Cap.	.169	.169	.172	.180	.195
R ₂₃ P. P. P. Cap.	.170	.171	.177	.194	.224
R ₂₄ Other Mfg. Cap.	.174	.175	.180	.196	.224
R ₂₅ Bldg & Constr. Cap.	.163	.164	.170	.190	.225
R ₂₆ Publ. Util. Cap.	.171	.172	.177	.192	.220
R ₂₇ Trans. & Comm. Cap.	.170	.171	.178	.199	.236
R ₂₈ Distribution Cap.	.166	.166	.167	.170	.176
R ₂₉ Bank. & Ins. Cap.	.179	.179	.179	.182	.186
R ₃₀ Services Cap.	.093	.171	.175	.187	.208
R ₃₁ Govt. Inv. (autonomous)	1.186	1.184	1.189	1.203	1.228
R ₃₂ Ownership Cap.	.181	.181	.181	.181	.180
R ₃₃ Ownership Inv. (autonomous)	1.208	1.206	1.205	1.203	1.201

TABLE IXF

Effect of Lowering Immigrants' Consumption Requirements
(Shadow Prices)

<u>Solution No.</u>	1	16	17	18	19
<u>Min. cons. (\$mn/'000)</u>	<u>1.0</u>	<u>0.9</u>	<u>0.8</u>	<u>0.5</u>	<u>0.0</u>
R ₃₄ Foreign Exch.	1.141	1.164	1.304	1.731	2.480
R ₃₅ Savings	-	-	-	-	-
R ₃₆ Labour	2.782	2.741	2.570	2.045	1.129
R ₃₇ Max. Farm. Exp.	.097	.123	.276	.708	1.480
R ₃₈ Max. For. Exp.	.087	.114	.266	.731	1.545
R ₃₉ Max. For. Proc. Exp.	.130	.155	.298	.735	1.502
R ₄₀ Max. H. & F. Exp.	-	-	-	.199	1.125
R ₄₁ Max. Mining Exp.	.010	.035	.174	.599	1.342
R ₄₂ Max. P. P. P. Exp.	-	.026	.170	.613	1.387
R ₄₃ Max. Oth. Mfg. Exp.	.099	.121	.252	.650	1.347
R ₄₄ Min. Imm. Cons.	.931	.931	.937	.953	.981
R ₄₅ Total Cons.	-	-	-	-	-

The result is that consumption per head gradually decreases (Table IXC). The model appears to behave in such a way that, once the first increase in activity has taken place, substitution between immigrants' consumption and indigenous consumption occurs and all the other variables remain at about the same levels.

However, an examination of the shadow prices shows that as the level of income for immigrants is neglected there is a complete change in the policy priorities dictated by the model. There is a gradual reversal of the relative scarcities of foreign exchange and labour, and marked increases in the opportunity costs of the restrictions on exporting activities (Table IXF). It would be the same basic forces which cause the model to choose the consumption activity with 10 per cent import substitution (Table IXC) and the marginal productivities of capital to rise (Table IXE).

In short, failure to allow a reasonable level of consumption for immigrants will cause higher levels of immigration to be programmed and something will be sacrificed in terms of consumption per head. The overall level of activity in the economy will not change much, but the increased numbers of immigrants will put pressure on the balance of payments while going some way towards relieving labour shortages.

This feature of the model, therefore, gives policy makers an important guide as to priorities within the assumptions of the model, for immigration. If minimum standards for immigrants are not set, the programme suggests that optimal policy would require higher levels of immigration. However, this would result in lower incomes per head and increased strain on the balance of payments. It is possible that there could be other economic or social arguments for immigration, but the policy maker has, from the model, a warning that he should also assess the likely balance of trade situation.

(6) Capital Requirements for Immigrants

It was thought that the reluctance of the model to include large amounts of immigration might be due to the heavy capital requirements incorporated. Immigrants are likely to be more efficient users of capital than indigenous New Zealanders in that they are prepared to live in smaller houses, work longer hours and so forth. For this reason it was decided to reduce the housing capital requirements by 10 per cent and 20 per cent, but the effect on the optimum solution was negligible. It will be recalled that in most runs of the model, savings for investment was not a limiting factor to growth, so it is not surprising that reduction of immigrant's capital requirements has little effect on the solution. The model has, however, proved to be sensitive to different foreign exchange situations and, in view of the strong interdependence between investment and importing, it would possibly be useful to repeat this experiment for a number of export income assumptions.

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APPENDIX

Definition of Sixteen Sectors andCompilation of Data

The sixteen sectors on which the results of this study are based are:-

- (1) Farming: This sector encompasses the whole of farming in New Zealand : Livestock, cropping, horticultural produce, poultry and agricultural contracting.
- (2) Forestry and Logging: The establishment, maintenance and harvesting of trees.
- (3) Forest Processing: The processing of raw timber into sawn timber and other building materials or fittings, and the processing of raw timber into pulp and paper products.
- (4) Hunting and Fishing: The production of raw fish, and pest extermination and acclimatisation activities.
- (5) Mining: Mainly composed of coal production and limestone production.
- (6) Primary Produce Processing: The production of frozen and preserved meat, the production of butter, cheese and other dairy products, and the freezing and preserving of fruit and vegetables.
- (7) Other Manufacturing: This sector comprises all secondary or manufacturing industries not already included in forestry processing or primary produce processing - the list includes food manufacturing industries, textile industries, printing industries, rubber and leather processing, production and processing of chemicals, fertilisers and animal by-products, all forms of heavy and light metal working, vehicle assembly and repair, and others.

- (8) Building and Construction: All building construction and the construction of civil engineering structures and roads; building repair.
- (9) Public Utilities: The production of electricity and gas, and the provision of water and sanitation.
- (10) Transport and Communication: All forms of land, sea or air transport activities plus the activity of the New Zealand Post Office (excluding the Post Office Savings Bank).
- (11) Wholesale and Retail Trade: The activity of establishments responsible for the distribution of goods produced elsewhere; the output is valued not at the retail value of the goods handled, but at the wholesale to retail margin; this is considered to be the value of the service of distribution.
- (12) Banking and Insurance: Banks, insurance companies and other financial organisations.
- (13) Services: Education, medical, legal, accounting services, and all forms of professional or technical advice; restaurant and accommodation services; personal and miscellaneous services such as undertaking, dry-cleaning, carpet laying, etc.
- (14) Services to Households: Services in which wages are paid directly to the labour involved by private consumers (servants, household help) or by non-profit organisations (paid secretaries of sporting clubs).
- (15) Services to Government: Wages paid by the government and other public authorities for administrative activities or for the maintenance of law and order.
- (16) Ownership of Property: All imputed and real landlord activity; the value of output is the imputed rental value of owner-occupied houses plus the actual rental value of non-owner-occupied houses and business premises.

The coefficients for the current production activities were derived from Table VII, page 52, Ross and Philpott [11]. These coefficients have been adjusted to account for extra output that will be required to replace obsolete and worn-out capital equipment. The total amount which is added to the coefficients of an activity is equal to the depreciation coefficient (proportion of total output) for that activity; this amount is distributed among the inputs for that activity

in the same proportions as it would be for net investment, except that it is weighted against input from building and construction by a factor of five; this is an attempt to account for the fact that building capital does not need to be replaced as quickly as plant and machinery.

The capital-output ratios, the capital coefficients, and the labour-output ratios are the same as those used by Ross and Philpott [10] and their values were obtained by private communication with Professor B.J. Ross. The labour-output ratios have been adjusted for the expected productivity rise by 1972/73. The capital-output ratios are really incremental capital-output ratios; the assumption is made that average capital requirements of all sectors are the same as capital requirements at the margin.

The reason for the values of 6.6667 connecting the final year investment flows to the final year capital stocks have been given in Chapter IV, Sec. 4.4 and Chapter III, Sec. 3.4.[7]. Table 1A shows a series of values for the proportion of total investment in an eight year period which will occur in the final year at a number of annual growth rates in the level of investment. The calculations are similar to those used by Manne [2] and described in Chapter III, Sec. 3.4. [7]. From this table it is seen that if the annual growth rate in investment is around four or five per cent, approximately .15 of the investment during an eight year period will occur in the final year. This means that total capital formation during an eight year period will be $1 \div .15$ or 6.6667 times the level of investment in the final year.

TABLE 1A

<u>Fraction of Investment Occurring in Final Year</u>				
<u>of Eight Year Horizon assuming Constant</u>				
<u>Annual Rate of Growth</u>				
Annual Growth Rate	3%	4%	5%	6%
$(1 + g)^8$	1.2668	1.3686	1.4775	1.5938
$g(1 + g)^8$.0380	.0547	.0739	.0956
$[(1 + g)^8 - 1]$.2668	.3686	.4775	.5938
Proportion in final year	.1424	.1484	.1548	.1610

The coefficients for the consumption activities are calculated from the 1964/65 interindustry statistics [1], the import saving alternatives being calculated in the manner described in the text. The immigrants' consumption activity has the same coefficients, but the coefficient for services to government is omitted on the grounds that there is not likely to be a large direct increase in the level of administration due to immigrants; the extra organisation required should be indirectly accounted for by the capital requirements of immigration.

The capital requirements for immigrants are calculated from the estimated needs of immigrants for social capital suggested in the Monetary and Economic Council Report No. 12 [3]. The coefficient of -0.50000 is due to an assumption that every 1000 immigrants results in an addition of 500 to the labour force. This is a rounded off estimate of the figure published in the Monetary and Economic Council Report.

The capital stock availability figures are obtained artificially. It is assumed that in the base year, 1964/65, all sectors of the economy are operating at the full capacity of their capital stock. An artificial figure for "capital stock" can therefore be obtained by dividing the capital-output ratio into the base year level of output for each sector. This was done for all sectors except "Ownership of Property", a sector in which most of the investment has to be decided upon independently. However, some investment must occur within the model to allow for the building of premises to be leased or rented to the productive sectors; it was estimated how much of the 1964/65 output was of this nature, and the same proportion of the total "capital stock" for the sector was used.

The maximum overseas deficit for the target year, 1972/73, was chosen as \$60 million in line with that suggested in the Targets Committee Report of the National Development Conference [12], page 11.

The labour force availability was calculated from the labour force projections published in the New Zealand Year Book. Since these are published for calendar years, the figure used is a weighted average of the figures published for 1972 and 1973. The projection assuming zero net immigration was used as immigration is endogenous to this model.

The upper limits to the levels of the exporting activities were varied considerably for different solutions of the model, but their values were based on the export requirement computed by the Lincoln projection model. These, in turn, were in line with studies made by the sectoral working committees set up by the National Development Conference.

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