INPUT OUTPUT ANALYSIS FOR REGIONAL AND LAND USE EVALUATION WITH PARTICULAR REFERENCE TO FORESTRY

by

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A thesis submitted for the degree of Master of Science at the Australian National University.

March, 1974

PREFACE

The work reported in this thesis was conducted by the author at the Department of Forestry, Australian National University. None of the original work in this thesis has been submitted previously for a degree at this, or any other University. Information derived from other researchers has been specifically acknowledged either as personal communications, or in a list of references appended.

J.J. Douglas

March, 1974.

ACKNOWLEDGEMENTS

I wish to express my gratitude to my supervisor, Mr E.D. Parkes, for his valuable assistance and guidance through all stages of this work.

My thanks are also due to Mr T. Johnson of the Department of Forestry, for his assistance in the computational work associated with this thesis, and his major part in formulating the mathematical proof presented in Chapter 5.

I am indebted to the head of the Forestry Department, Professor J.D. Ovington, and to other staff members and post-graduate students at the Australian National University, for their help in provision of facilities and information. I would also like to thank the various officers of Federal and State Government Departments who assisted with the supply of data.

I am grateful to my employer, the Forestry Commission of New South Wales, for allowing me leave of absence to carry out this work, and to the Institute of Foresters of Australia, whose award to me of the Alan R. Henderson Bequest in 1971-72 provided some much needed financial assistance.

For their help in various ways in this work I would like to thank Chris Douglas, Ogilvie Douglas, Mrs Norma Wallace, Silvia Xavier and the members of LOM.

ABSTRACT

In the area of forestry economics, and indeed land use economics as a whole, there has been a tendency to analyze projects from the rather restricted viewpoint involving only their direct market costs and benefits. It is a fundamental argument of this thesis that, where government and thereby society in general have an interest in an investment the indirect economic effect of that investment should be evaluated because they can be as important as the direct effects. Further, it is argued from the evidence presented that inferences about the nature and magnitude of indirect effects can not be drawn from quantification of the direct effects.

Since the forestry industry was specifically examined in this thesis, it was necessary to place the industry in both its economic and international perspective. This is done in the introductory chapters. A review of government investment criteria, particularly those relating to land use evaluation follows. This review outlines the basis for including indirect economic effects into this type of analysis.

Having argued the necessity of including the indirect economic effects it was necessary to discuss the problems of how this may best be done. Although for regional analyses, many examples of the use of economic base models are available in the literature the alternative technique of input output analysis has usually been restricted to multiple industry analyses of national or large scale regional projects. However, it is shown in this thesis that this technique can be adapted

to analyzing in detail the total influence of one sector. Some regional forestry examples are presented to demonstrate how limited regional data can be imputed into a national input output model, to yield specifid information about indirect economic effects of an industry on either a regional or sub-sectorial basis.

At the national level it will be seen from the results obtained that the multiplier effects of the various land using industries examined vary widely, both in magnitude and effect. The regional forestry figures developed for this thesis point out the widely varying nature of indirect effects within a nationally defined sector, and also provided interesting information on the structure of the industry and how this may be expected to change over time.

Considerable attention is given in this work to the examination of the two major problems associated with input output analyses - coefficient drift and aggregation distortion. Results presented show that coefficient change over time is a serious problem in the Australian case - and the need to use refined updating techniques and periodical re-assessment of input output data is obvious. The aggregation problem was examined specifically with a view towards producing reduced, special purpose models for multiplier analysis. This has important implications not only for condensing existing models, but for the ability of those existing models to accurately represent the economy.

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INTRODUCTION

FORESTRY IN AUSTRALIA

The forestry industry in Australia is, by international standards, a relatively small one. In terms of land availability, less than 10% of the total land surface has any potential for production forestry (FORWOOD (44)). In comparison, around 28% of Canada is already under productive forest, and in the U.S.A. the figure is 22% (USDA (90)). The total output of the forestry sector has risen to $150m annually, whereas a single agricultural industry - the wool industry - adds over $800m to Gross National Product annually (Evans et al. (33)). Australia produces about 1 cubic metre of wood per capita per annum, (Forest Graphs (42)), while equivalent figures for Finland, Canada and the United States are 11.2m^3 (Ervasti et al. (31)), 5.1m^3 (DFF (op cit)) and 1.9m^3 (USDA (op cit)) respectively.

These figures, however, understate the importance of the industry to the Australian economy. Firstly, the continuation of the large plantation programme will increase the size of the resource. While some reservations have been expressed as to the wisdom of continued federal loans under the Softwood Agreement Act in the Coombes Report (23), it is certain that at least the current five year programme will proceed. Secondly, the indirect economic stimulation effect of this industry is greater than for most other primary industries. It will be shown later in this thesis that, where the net social benefit is at interest when forestry projects are being considered, the indirect effects can have at least as important an influence as the direct economic effects. Further, it will be argued that the quantification of a range of indirect effects is a more fruitful area of research for the land use analyst than is the investigation of more restricted, direct criteria.

One such direct criterion which has been commonly advanced as a rationale for extension of plantations in Australia is the foreign exchange argument. Indeed, the original impetus given to the Softwood plantation schemes in the mid sixties was the conclusion in the Vernon Report (91) that it would become necessary to produce more wood locally to maintain the national standard of living. One of the principal reasons given in the report for this claim was the necessity to reduce the balance of payments deficit. Due to the unprecedented capital inflow into Australia over the last few years, the predicted balance of payments deficit has not eventuated but whether this is a permanent situation is difficult to predict. The foreign exchange argument, as it is commonly presented by forestry planners, has a more serious flaw. Results presented in Chapter 4 of this thesis will show that where the total, rather than only the direct balance-of-payments effects are taken into account, the capacity of the forestry industry to positively influence foreign exchange balances is considerably less, per dollar invested, than for the other land use industries examined. Thus, the argument of foreign exchange saving as a reason for investment in forestry <u>per se</u>, is not convincing. However, if it can be shown that world wood and wood substitutes prices are rising in comparison to Australian wood products prices, then wood is likely to become a more strategic commodity than at present and the foreign exchange criterion will assume greater importance.

The Economic Study Group (26) set up to investigate the economics of the Australian timber industry concluded that the basic log intake necessary to allow a sawmill to achieve economics of scale and operation is between 14,000 and 19,000 cubic metres per annum. At the time of the study, only 4% of mills had intakes equal to a greater than this level. Trends indicated in Forest Graphs (op cit) show that the situation is improving slowly, and provided that this improvement is faster than the rate of cost increases, the increased efficiency should result in reduced real timber prices in the future.

The decline in per capita consumption of sawnwood in Australia can broadly be attributed to the development of economic substitutes, change in dwelling types and economies of design (such as the age of pre-fabricated roof trusses, and the introduction of the Light Timber Framing Code by the Standards Association of Australia in 1971). If current market price trends for standard timber and its main non-wood substitutes (steel, aluminium and concrete) are extrapolated, the future for structural timber appears unfavourable. It is fairly clear, however, that the current swing in economic thought towards welfare considerations and social costing will profoundly affect the relationship between these products.

As long ago as 1920, A.C. Pigou theorized that private and social costs of a production process should be equalized by taxation, and other government interventions. Reference to some of the working papers of the Club of Rome sponsored study on the "Predicament of Mankind"[1] (Meadows *et al.* (72)) indicate that the current market prices for certain raw materials and power input may seriously underestimate their real social costs because of predicted shortages and environmental problems. More specifically, Dane (24) has presented figures on the social costs of producing structural materials in the United States. Using as a basis the cost per lineal foot of wall, inclusive of the costs of avoiding environmental despoilation in the production process, it can be concluded from Dane's results that if social costs were charged in full to the consumer, then timber would become cheaper than steel, concrete or aluminium.

Plastics are also in competition with sawn timber in some areas. Indeed, in a comprehensive analysis of the prospects and trends in wood/plastics competition, Runeberg (1973 (83)) claims "the building industry is without doubt one of the most important fields in which timber and plastic will fight for a place in the sun". In an earlier paper Runeberg (1969 (82)) concluded that the usage of wood/plastic composites for structural and furnishing uses was growing faster than the usage of either product individually in Finland.

The situation for pulp and paper products is more difficult to predict. Most forecasts of per capita consumption of wood pulp

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[1] Not that there is unanymity in academic circles as to the validity of the Meadows' team predictions (See, for example, Cole and Curnow in *Nature*, May 11, 1973).

products predict rising consumption against macroeconomic parameters such as personal disposable income, GNP and so on. Two related factors may militate against these trends continuing in the future. Firstly, there is concern for the potential environmental damage of high levels of consumption, and secondly the availability of substitutes - particularly plastics - must be considered. Runeberg's 1973 study shows that plastics are already making inroads into the wood pulp market, and will continue to do so. In terms of environmental damage (at least in manufacture, if not disposal) plastics are well placed to compete with conventional paper products. Runeberg is satisfied that the raw material for plastics will continue to be available for the forseeable future.[2]

Although plastics may well continue their current high rate of growth, this is not to say that existing per capita rates of wood based paper consumption will actually fall, but it appears certain that the current exponential growth rates in consumption will not continue in the future.

It is probably safe to suggest that, whilst exponential rates of consumption growth may still apply in underdeveloped regions for some time, this will be counterbalanced by diminishing growth rates in developed countries - so that the 'world curve' may be fairly close to linear.

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[2] Plastics at present are made from the otherwise useless naptha fraction of oil. Miller (Nation Review, July 13/19, 20/26 1973) is of the opinion that the current energy crisis in the U.S. exists largely in the minds of oil company executives, who can hardly be regarded as disinterested investigators. Notwithstanding current Arab nation oil supply constraints, there appears to be little substantial evidence to suggest that raw material for plastics will not continue to be available at a reasonable price.

In view of the above, the problem for the governmental forestry planner in Australia becomes one of deciding how much of the future requirement should be produced locally. Australia is in the position of being a residual market for wood products, with virtually no capacity to affect the world price of wood either by supply developments or demand manipulation. While this has the effect of making the nation vulnerable to undesirable price trends it at least simplifies the choice of remedies, in that market manipulation techniques have virtually no potential. Thus, from Australia's point of view, the decision as to how much of the predicted requirement should be grown locally can be discussed in the light of overseas price trends, (compared to local trends) and the indirect economic costs and benefits of a locally based forestry and forest products industry.

Real price movements overseas will of course be a result of changes in world market demand and supply. The aim of this thesis is not to exhaustively examine the literature on this topic and a more detailed analysis of the available information will be available in Chapter 6 of the Softwood Plantation Review, due for release by the Forestry Commission of New South Wales in early 1974. However, an outline of the important points is given below. Of all the references cited in that work, only two (Florence (40), Carter (13)) claim that supply of wood has some chance of keeping pace with demand, and even these are based on regional, rather than world wide figures. Since a large proportion of future wood supplies will necessarily come from under developed regions, Leslie's comments (60) are of interest. Leslie claims that only a slight depletion in existing growing stock from the underdeveloped regions would be necessary to supply predicted needs. However, he makes the points that:

1. Growing stock is likely to be more severely reduced in these regions due to agricultural expansion.
2. Social interest rates in developing regions are high, and thus utilization of the forest resource in these areas will probably be delayed until prices rise sufficiently to justify investment.

This point is difficult to accept per se. Foreign exploitation by United States and Japanese interests in the Philippines, Indonesia and New Guinea, for example, indicate that high profits are apparently forthcoming from such investments at current prices. However, it is reasonable to suggest that investment in the development of new resources, via plantations and/or silvicultural treatment in these areas will not be attractive until the product price rises considerably.

A third point is that the detrimental results of careless development experienced by the developed nations is likely to cause a number of underdeveloped nations to treat development with more caution. Hence, it is reasonable to assume that conservationist pressure may have a much greater impact at a relatively early stage in the development of these countries.

When the regional analyses generally referred to above are combined with more broadly based prognostications such as that given by Leslie, it is difficult to escape the impression that increasing demand, increasingly difficult access to supply and perhaps, in the very long term, absolute limits to supply, will cause the real price of wood to continue rising on the world market. Provided Australia can maintain reasonable control over costs, there would therefore seem to be some vindication of the foreign exchange argument.

However, as stated earlier, whether or not this is so does not affect the necessity to analyze forest land use from the total, rather than the direct, viewpoint.

The basic aim of this thesis is to examine the uses and limitations of input output analysis as an analytical tool to measure the direct and indirect effects of land use decisions.

Initially it will be necessary to investigate the need for such a technique in evaluating the economies of forest and other land use in Australia.

In Chapter 1, the argument is extended to a discussion of the importance of land use industries in government planning. In addition,a review of government investment criteria is undertaken, and the development of workable criteria by which a government may achieve the optimal allocation of funds is suggested for the land use industries.

In Chapter 2, the role of indirect economic effects on the optimal allocation of government funds is further discussed, and the application of input output analysis to this end is outlined. A simple model is introduced to illustrate the technique while a more precise definition of the model is presented algebraically.

Chapter 3 is a digression outlining a correction of an anomalous output figure in the input output model used for the analytical aspects of the thesis.

In Chapter 4, a modified input-output multiplier, which was developed to give a more accurate picture of the total effects of increased investments in the land use industries on the rest of the economy is introduced. A range of multipliers for several land use industries is presented, and the results are examined in the light of the preceding arguments for specification of the indirect effects.

Input output analysis has two major limitations which have been widely discussed in the literature; aggregation distortion and coefficient drift. In Chapter 5,a method for aggregation of large input output systems is presented and the important theoretical aspects of aggregation are discussed. A general proof of weighting requirements for aggregation is given, and this is discussed in relation to its implications for previous theory and published aggregation procedures. Some discussion of approximation methods for aggregation is given in Chapter 6, together with test results of using a range of aggregation procedures on the Australian input output tables. The applicability of these findings in developing a workable aggregated model is demonstrated at the end of the chapter, together with a 51 sector aggregated model of the Australian economy.

Chapter 7 discusses the problem of coefficient drift over time, and empirical findings related to Australian conditions are presented. The RAS updating technique is examined, and some theoretical comments are made.

In Chapter 8, both theoretical and practical aspects of imputing new data into the existing input output model are discussed. Modification of the forestry sector to present more realistic pictures of the industry is also carried out, and the results obtained using the 51 sector aggregated model presented in Chapter 6 are discussed.

CHAPTER 1

GOVERNMENT INVESTMENT IN LAND USE - AN OVERVIEW

1.1 INTRODUCTION

Investment in forestry projects, both in Australia, and in the world, is largely under the direct control of governments. Leslie (59) estimates that 70% - 75% of the world's forest resources are directly administered by government agencies, while in Australia the figure is around 60%. In view of this, it is not surprising that forest economists have long been concerned with the development of adequate criteria by which governments can make decisions related to forestry investment.

If national planners wish to optimise net social benefit, then they will have a different viewpoint and a different set of objectives to those of the private investor.

Usually planners need to know both the direct and the total economic effects of their decisions, regardless of the sector of the economy in which those effects are manifested. Moreover, national planners should take a different attitude to the effects of his decisions on employment and income distribution to that taken by the private investor.

The remainder of this Chapter will deal with the factors relevant to government decisions on forest land use, in order to place the findings presented in Chapters 2 to 8 in perspective.

1.2 MEASURING THE WORTH OF A FOREST INVESTMENT

The main differences between the government and the private investor's approach to investment decision can be demonstrated by listing the relevant costs and benefits pertaining to most forestry projects, and noting how they are accounted for from both the private and government viewpoint. (See Table 1.1).

These divisions are necessarily somewhat arbitrary - particularly in the case of social measures, which interrelate and overlap. Nevertheless, they provide a convenient framework for discussion.

1.3 CAPITAL

The return to capital of a forestry investment (or any investment, for that matter) can be calculated by use of the internal rate of return (IRR) (See Boulding (4)) or benefit cost ratio (BCR). Benefit cost ratios can be expressed with operating costs included in the denominator, in which case the ratio expresses the return per total dollar invested. Alternatively, the ratio may be expressed with the operating costs subtracted from the numerator, and will in that case express the return per dollar of capital invested. Net benefit/cost ratios can also be calculated. Because of these methodological variations, care must be exercised when comparing BCR's calculated by different agencies.

Both BCR and IRR techniques, and the use of the concept of net social supplies in general (See Mishan (74)), are of interest to the government planner, since they attempt to test the efficiency of use of capital - and capital is usually the main constraint.

TABLE 1.1 PUBLIC AND PRIVATE COSTS AND BENEFITS ASSOCIATED WITH A FORESTRY PROJECT

Cost or Benefit	Private Industry Measure	Social Worth Measure
CAPITAL	Minimum rate is the borrowing rate. Highest rate is the opportunity cost rate on alternative project	Minimum rate is the social marginal productivity of capital. Highest rate is the social opportunity cost of transferring funds from private to public investment. May have to use shadow price for capital if social rate of time preference is used.
LAND	Market price as cost. Discounted land expectation value as maximum, but including all relevant taxes and subsidies. (Annuity values may be used in preference to lump sum values). Market rent if leased.	Social opportunity cost value or social marginal productivity of land, adjusted to remove taxes, subsidies etc.
EMPLOYMENT	Market wage rate. Secondary effects are usually not applicable.	Opportunity cost value or net change in National Income.
RECREATION, EXTERNALITIES, INTANGIBLES	Costs of producing amenities. Rent for campers, shelter for company stock, agistment fees etc.	Costs of amenities and ecological and other effects on catchments, surrounding agriculture, society's leisure demand and psychological benefits.

A crucial factor when considering investment in forestry is the appropriate rate of discount. This is accentuated because of the long production period involved in forestry projects, and the irregular timing of the streams of costs and returns. Discussion in the literature on the appropriate rate of discount for government investment has fluctuated between those who advocate very low rates but high cut off rates (Eckstein (30)) to those who advocate rates higher than the prevailing private interest rate (Baumol (2)). Protagonists of low rates point to the greater ability of society as a whole to forgo present benefits for future gains, and be less mindful of risk, than the individual investor. However, both Turvey (88) and Heesterman (52) have concluded that most real preference functions are assymetric, because of risk aversion - indicating that the risk factor, even in government rates, may be too high.

Arguing for higher discount rates, Baumol claims that government investment incurs an opportunity cost, insofar as it removes investment capital from the private sector. Such an investment must therefore earn at the marginal before-tax private rate of return. Application of this principle _in toto_ seems to assume perfect liquidity between the public and private sectors, but nevertheless, its use in shadow pricing of capital transferred from the private to the public sector, is attractive.

The concept of a social time preference rate also has appeal but specifying such a rate for a given society is difficult (See Hufschmidt _et al_. (54), and Lind's (64) summing up of Marglin (71)).

Regardless of which rate of discount is chosen, attention must always be given to whether constant or current prices are used, and that the rate is adjusted accordingly, via the relationship;

$$(1 + f) = (1 + r)(1 + i) \quad \text{or} \quad r = \frac{f - i}{(1 + i)}$$

where

f = financial rate of discount

r = real rate of discount

i = rate of inflation.

1.4 LAND

In forestry and agricultural economics, present net worth (PNW) of a project has commonly been used to measure its efficiency of land use (See Gilmour and Reilly (45), Hoy and Sinden (53), Treloar and Morrison (87)). These studies use discounting to reduce all future costs and benefits to present values. There are some major problems associated with the use of this technique:

1.4.1 Inappropriate Maximand

As noted in Section 1.3 above, capital is often the primary constraint in government investment. PNW is not a good indicator of capital efficiency. A land use project that maximizes PNW may require a much heavier capital investment per unit area than a lower PNW alternative. Earl (29) has suggested that this may be overcome by the imposition of capital constraints, and then using PNW formulations within these capital limits.

1.4.2 Methodological Limitations

Most forestry evaluations are based on the use of Faustmann's Formula. Grainger (46) has warned against the indiscriminate use of this formula, particularly where a forestry alternative is being compared to a non-forestry project. Two assumptions implicit in the formula are possible sources of error;

(i) The 'average acre' assumption requires that all acres in the project must be planted in year 1, and harvested in the final year of the rotation. For large projects, it is unlikely that this will be so. Parkes (79) has suggested that more realism may be obtained by use of the following modification:

$$PNW_{(sy)} = \frac{PNW_{(F)}}{n} \times \left[\frac{(1+i)^n - 1}{i(1+i)^{n-1}} \right]$$

where,

$PNW_{(sy)}$ = Sustained yield PNW

$PNW_{(F)}$ = Faustmann Formula PNW

n = Rotation length

i = Discount rate

This formula calculates the PNW of an investment intended to produce a sustained yield plantation by establishing 1/n of the total project area each year – i.e. the establishment of a 'normal' forest.

Most plantations, however, are not established in such a regular fashion, but rather have an accelerated planting programme early in the first rotation. (See Fenton (34)). Probably the most satisfactory solution to this problem is to use a programming approach, such as the one currently in use by the Forestry Commission of New South Wales.[1]

[1] The RADHOP System, held in Commission records and computer files.

These models have a facility to allow for variation of establishment and harvesting times through the life of a plantation.

(ii) The specification of annual administrative costs as a constant in the formula is not appropriate for most real operations. When such costs are relatively small, this is an acceptable approximation. Otherwise, a budgeting approach, such as that used by Fenton (op cit), is more appropriate.

1.4.3 Valuation of Inputs and Outputs

Most published forestry/agriculture land use comparisons have based their revenue calculations on market prices. McCarthy *et al*. (op cit) have warned against this practice when the net social benefit is to be maximized. Certainly, in the case of agriculture in Australia, there exists a complicated network of price support schemes, subsidies, bounties, taxation concessions and so on. Two projects producing different commodities cannot be compared from the national viewpoint until all such 'artificial' influences on the market prices are removed.

Even if shadow prices are used there exists the very real possibility of differential price changes over time. Parkes (79) and Fenton (35) have demonstrated the marked response of forestry investment to changes in product prices. Where forestry investments are being compared to other land uses, the use of of the constant price assumption[2] is only valid when:

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2 Virtually all published forestry/agriculture comparisons in Australia use this assumption (See, for example, references (45), (53), (87)).

(i) The prices of all inputs and outputs of the industries being compared are either static or changing at the same rate;

(ii) The discount rate being used is adjusted by an amount equalling the rate of price change (as outlined in Section 1.3 above). Clearly, in times of rapid inflation, a discount rate defined when product prices were not changing so quickly would be inappropriate.

Condition (ii) above is usually able to be met if the rate of discount is based on the social opportunity cost of capital. However, it is relatively simple to demonstrate that condition (i) is rarely met in practice. Douglas and Watt (28) have used fairly simple extrapolation techniques to show that incorporation of historical real price trends into a forestry/agriculture comparison markedly alters the constant price PNW values, and in some cases reversed the ranking of the projects involved.

1.5 EMPLOYMENT

It is common in cost/benefit analyses to assume a full-employment economy. While this obviates the necessity to perform any analysis of the shadow price of labour, it clearly causes over-estimation of the social costs of labour when there is unemployment. Turvey (op cit) argues against allowing for this overestimate for the following reasons:

(i) Correcting future costs requires future estimates and these, for practical or purely analytical reasons, may not be available to the researcher. Practical difficulties do not, however, remove a theoretical necessity.

(ii) The effect of a project on unemployment is to some extent a function of how the project is funded. Turvey claims that this may not be known to the researcher, although in Australia this is unlikely to be the case.

(iii) It is easier to allow for overpricing of direct labour input than to allow for the overpricing of fuel, equipment and other inputs required for the project caused by the overpricing of labour in the supplying industries. Turvey claims that allowing for project labour overpricing without adjusting input prices as well may estimate the relative social costs of labour and all other inputs more poorly than if corrections were not made.

Weingartner (92) calculated shadow prices for resources over time using a linear programming model. The model calculates the opportunity cost or marginal product of the resources for each time period involved - and allowed for variation in the rate of discount over time as well.

Haveman and Krutilla (51) have devised a method for obtaining the total labour effects under varying conditions of employment. Their model utilized a series of regional input output models linked to a national model. This system was combined with an industry/occupations matrix.[3] The process allowed the final bill of goods for a project to be related to the factor sources which supply the primary inputs. By then comparing occupational labour demands with rates of unemployment by occupation, an estimate of the total effect of the project on the idle pool of labour can be made.

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3 In Chapter 4, it will be seen that such a matrix can be developed for Australia using existing data.

Turvey (op cit) criticizes this approach on a number of points. Some of these relate to the various fundamental assumptions implicit in input output analysis in general and these will be discussed later in this thesis. More specifically, Turvey claims that Haveman and Krutilla's assumption that supplying firms will automatically increase output in response to an increase in demand, may not be valid. Turvey raises the possibility that the firms may supply goods to a new project at the expense of regular buyers. However, it seems reasonable to assume that, as the unemployment is high (and presumably all factors of production are under-employed) firms will tend to increase output in response to new demand.

Results obtained in this thesis indicate that inter-industry methods can readily be used to investigate a range of effects a project has on the economy, i.e. balance of payments, income distribution, taxation flows, subsidies and tariff effects.[4] At this stage, it would seem more beneficial to concentrate on including these effects into cost benefit analyses, rather than to develop more rigorous analytical details of the existing techniques.

1.6 EXTERNALITIES AND INTANGIBLES

Since the concept of multiple use forestry was emphasized at the Ninth World Forestry Congress, much general discussion has arisen

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[4] An input output model is already being used to investigate the effects of the tariff structure in Australia (See Evans et al.(33)).

in the literature. However, little methodological work has appeared, mainly because of the difficulty of evaluating certain of the non-wood benefits of forests. Richardson (80) has strongly criticized the use of the multiple use argument as a justification for unprofitable forestry operations, and he claims more thought should be given to the concept of managing areas either to maximize wood production, or as purely recreational forests.

Both supporters and critics[5] of various forestry practices in Australia use the valuation of externabilities and intangibles to support their claims. Certainly, in the case of externalities, the costs and benefits of certain types of forestry can be quantified, and, in any large scale forest investment analysis, this should be done. Intangibles will probably continue to be valued subjectively or expressed as opportunity costs - either way value judgments on their desirability must be made. However, work along the lines of Ferguson and Grieg (37) shows that some progress in the specification of a demand function for certain intangible benefits can be made.

1.7 SUMMARY

This chapter has been a brief summary of the factors of concern to the land use economic analyst. It has been pointed out that, where the national or social interest is of primary concern, the total, rather than only the direct economic effects of land use projects should be

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[5] See, for example, Routley and Routley (81).

specified. Haveman and Krutilla's work is an example of how inter-industry analysis may be applied to this aim - in that example the employment effects were quantified. Inter-industry methods have similar potential for analyzing the total effects of subsidies, bounties, tariffs, taxation payments, balance of payments factors and so on. In a more general sense, inter-industry analysis of land use industries can yield much useful information about the structure of those industries, and about their relationship to the rest of the economy.

The remainder of this thesis will discuss various theoretical and practical aspects of the application of inter-industry methods to land use evaluation. The following chapter contains a basic statement of the model, and some discussion of its limitations and previous applications.

CHAPTER 2

INPUT OUTPUT ANALYSIS - A DESCRIPTION OF THE MODEL AND ITS APPLICATION TO LAND USE EVALUATION

2.1 INTRODUCTION

In the previous chapter, the important factors which influence investment in land use projects were discussed. The factor most neglected in Australia is the indirect economic effects. These are defined as being economic effects caused by a given industry but manifested in other parts of the economy.

If it can be shown that these effects are significant, and that for any given factor input they are not necessarily correlated to direct effects, then they cannot be ignored when selecting that set of projects which optimize net social benefits. It will be shown in chapter 4 of this thesis that the indirect effects of certain land using industries in Australia on factors such as labour, taxation generation, imports and so on can be quite different to their direct effects.

The use of input-output multipliers is often regarded as an alternative to the use of economic base multipliers, in specifying total rather than direct effects.More discussion of this point is given in chapter 4. Normally, input-output multipliers are applied to large-scale economic planning, involving many or all of the sectors being examined. The following chapters will show that it is also an effective tool for assessing the effects of changes in one industry, or a small group of industries, on the economy as a whole.

The technique has the unique ability to resolve the intricacies of inter-industry relationships through sets of simultaneous linear equations.

2.2. THE BASIC MODEL.

"Input-output analysis is a practical extension of the classical theory of interdependence which views the whole economy of a region, a country or even the entire world, as a single system and sets out to interpret all of its functions in terms of the specific measurable properties of its structure."[1]

The fundamental concept of the input-output model is to represent in matrix form the inter industry transactions taking place within the economy. These are usually, although not necessarily, expressed in money terms.

The interindustry flows of goods and services are tabulated in a square matrix such that all the inputs, into a given sector are recorded in the column headed by that sector, and all the outputs from that sector are recorded in the row headed by that sector. It can be seen that this system provides a means of assessing the input any sector receives, or the output it supplies, to any other sector.

Consider a simple economy which consists of only three sectors; Forestry, Sawmilling and Labour. The input-output model of the cash flow is given in table 2.1.

TABLE 2.1

CASH FLOWS IN A 3-SECTOR ECONOMY

Purchases Sales	Forestry	Sawmilling	Labour	Total
Forestry	10	80	14	104
Sawmilling	5	10	85	100
Labour	89	10	4	103
Total	104	100	103	

[1] W.Leontief, in "Input Output Economics"(62)

The model shows that, for Forestry to maintain its production, it requires inputs of $5.00 from the Sawmilling industry, $89.00 from the Labour sector, and $10.00 from itself. These values are based on a given time interval - usually a year.

Looking at the output row of the forest sector, it will be seen that of the $104 worth of goods produced, $80 worth goes to the Sawmilling industry, $10 worth is uded by the Forestry industry itself, and the balance goes directly to the Labour sector. The same interpretation can be placed on the values of the rows and columns of the Sawmilling industry,and the Labour sector.

For the model to be in balance, the row and column total for any sector should be equal. In this simple model, all transactions are treated endogenously, while final demand is simply the purchases made by the Labour sector. In large open models, the various components that constitute final demand in the real world are determined exogenously.

The input-output table as presented has only limited descriptive use. Before detailed analysis can be undertaken, the values in the table have to be converted from cash flows to input coefficients. Input coefficients are calculated by dividing the value of the purchases from each sector by the total value of all the inputs into the sector being considered.

The three input coefficients relating to the Forestry sector are obtained by dividing the three input values discussed earlier by the total purchases of the Forestry sector - $104 in this case. The coefficients so derived are sometimes referred to in the literature as technological coefficients

TABLE 2.2

INPUT - OUTPUT COEFFICIENTS

	Forestry	Sawmilling	Labour
Forestry	.096	.800	.136
Sawmilling	.048	.100	.825
Labour	.857	.100	.039
TOTAL	1.000	1.000	1.000

A check of the calculations can be made by summing the elements in each column, which should total unity in each case.

The working of the model can now be examined by assuming that the Labour sector changes its pattern of purchases. Assume, for example, that the purchasing pattern of the Labour sector changes to the following values:

$20 from the Forestry Sector
$100 from the Sawmill sector
$110 from the Labour sector.

It is apparent that to meet this new level of demand from the Labour sector, both the Forestry sector and the Sawmilling sector will need to increase their levels of output.

First Round.

In Table 2.1, the Forestry sector's sales to the Labour sector amount to $14.00, whereas under the new purchasing pattern the Labour sector increases its purchases from the Forestry sector to $20.00 - i.e. an increase of $6.00. Assuming the relationship between industries is preserved, it can be seen from Table 2.2 that a $6.00 increase in output from the Forestry sector requires an increased input of $0.576 (0.096 x $6.00) from itself, and an increased input of $0.288 (0.048 x $6.00) from the Sawmilling sector

The Sawmilling sector has increased its sales to the Labour sector by $15.00. Following the same reasoning as above, this will require that the Sawmilling sector increase its purchases from itself by $1.50 (0.1 x $15.00) and its purchases from the Forestry sector by $12.00 (0.8 x $15.00).

Therefore, in this first round, Forestry has increased its total output by $12.576, and Sawmilling by a total of $1.788.

Second Round.

Inputs required to produce these increased outputs require increased outputs from the two supplying sectors. To meet its increased output of $12.576, Forestry will need to purchase from itself a further $1.207 (0.096 x $12.576) worth of inputs. The Sawmilling sector will need to purchase $1.43 (0.8 x $1.788) worth of additional input from the Forestry sector. Thus, the increased output required in the second round from the Forestry sector will be $2.64. Similarly, the increased output from the Sawmilling sector will be $0.782.

Therefore, after the second round, the total increase in output required from the Forestry sector is $6.00 + $12.576 + $2.64 = $21.213. From the Sawmilling sector, the equivalent figure will be $15.00 + $1.788 + $0.788 = $17.57.

Obviously, if this iterative round by round procedure were continued, successively diminishing increments would result. Equally obviously, this iterative approach is rather impractical for solving for changed levels of demand in input-output systems - particularly as the number of sectors involved increases. An alternative method of solution is available through the use of matrix algebra, whereby the system is represented by a system of simultaneous equations. The system of equations can be solved using the standards techniques described in most textbooks on input-output analysis (see, for example, Leontief et al (63)).

In general, the standard input-output expression shows that for an m x m input-output system, where;

A = (m x m) matrix of input coefficients.

I = (m x m) identity matrix.

X = vector of total sector outputs of dimension m.

Y = vector of final demands of dimension m,

then;

$$[I - A]^{-1} Y = X$$

This approach can now be used to solve the numerical example given previously by expressing it as a 2 x 2 interindustry system, with an exogenous Labour sector. In this case, the system is represented by the following matrices;

$$A = \begin{bmatrix} .096 & .800 \\ .048 & .100 \end{bmatrix}$$

$$Y = \begin{bmatrix} 20 \\ 100 \end{bmatrix}$$

The 2 element vector of total outputs (X) becomes the unknown, so that;

$$\begin{bmatrix} X_1 \\ X_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} - \begin{bmatrix} .096 & .800 \\ .048 & .100 \end{bmatrix}^{-1} \begin{bmatrix} 20 \\ 100 \end{bmatrix}$$

and since,

$$\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} .096 & .800 \\ .048 & .100 \end{bmatrix}^{-1} = \begin{bmatrix} 1.1600 \\ 0.0590 \end{bmatrix} \begin{bmatrix} 1.0311 \\ 1.1636 \end{bmatrix}$$

$$\therefore \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} = \begin{bmatrix} 1.1600 & 1.0311 \\ 0.0590 & 1.1636 \end{bmatrix} \begin{bmatrix} 20 \\ 100 \end{bmatrix}$$

Thus, from matrix multiplication,

$X_1 = 126.31$ and $X_2 = 117.53$

From the round by round solutions above, the new total outputs after two rounds were;

$X_1 = 125.213$ and $X_2 = 117.570$

and these are reasonably close to their matrix algebra solution counterparts. Rounding errors account for the slight overestimate for X_2 given by the round by round approach since, in theory, this method should underestimate the total output requirement to some degree.

The example given above demonstrates an important application of input-output analysis in quantifying the repercussion effects generated within the economy by a specified change in the consumption pattern.

2.3 FACTORS OF IMPORTANCE IN THE PRACTICAL APPLICATION OF INPUT OUTPUT MODELS

The factors which must be accounted for when applying input output models are coefficient drift and aggregation, accounting discrepancies and valuation of government services.

The two major problems associated with static input output models, coefficients drift and aggregation distortion, are discussed in detail in chapters 5,6 and7. The United Nations publication on input output analysis (89) discusses several other limitations. These are for the most part related to the two major ones and cover such matters as time lags, sector definitions, linearity and the necessity to use average, rather than marginal propensities, and lack of dynamic change in the models.

Two points which do not relate to these two major limitations are; accounting discrepancies and valuation of government services. Accounting discrepancies, when they arise, will tend to disrupt the balance of inputs and outputs. If the imbalance is serious, then a re-assessment is necessary. If it is not, then discrepancies can be allocated to an undistributed sector - usually a balancing row in the matrix. This method firstly allows the amount of error present to be observed and secondly avoids the compounding of the error that would almost certainly occur if the error was arbitrarily distributed through the inputs and outputs.

The output of government services can be difficult to assess because the services that governments provide are not always charged for directly according to their real value. Normally this problem is overcome by estimating output on the basis of current and capital expenditure in the Government service industries.

2.4 SOME PREVIOUS APPLICATIONS OF INPUT OUTPUT ANALYSIS TO THE FORESTRY SECTOR.

Input output analysis has not been widely applied in forestry economics or indeed in the area of land use economics in general.

Ferguson (36) has used the 54 sector Western Australian model (Parker (78)) to predict the effects of a wood chip industry on that economy. Two interesting points can be made from this work:-

1. Since a wood chip industry did not exist in the area at the time of the study, the writer proposed that the forestry, sawmilling and road transport industries could be used as indicators of the type of linkages which the wood chip industries would have. There is in fact a good chance that the accumulation of indirect effects in the secondary and tertiary industries would be quite different for a wood chip industry than for these industries and therefore the indicators are of limited value only. If however, it <u>could</u> be established from empirical evidence that existing industries can be used in this indicative

manner, then the implications for evaluating future projects on the basis of current data is obvious.

2. It is not clear from the paper how the aggregation of the economy into three large sectors was made, but the findings on aggregation outlined in chapters 5 and 6 of this study would indicate that an aggregation of this order would probably not give an accurate indication of the indirect effects. Whether or not the order of inaccuracy is sufficient to affect the conclusions drawn is difficult to decide. Whilst the specific conclusions of the study are not relevant to this discussion, the general finding that indirect effects are higher than was previously thought is important. Certainly it is characteristic of input-output analysis to indicate a higher order of indirect effects than more informal methods, simply because it is able to carry the assessment of these effects through to a much more complete stage, particularly when large matrix systems are being used.

Zaremba (94) used the input-output model in a standard way, to quantify the effects of an increase in final demand for forest products on the forestry and other sectors. He concluded that interindustry modelling has a definite place in demand forecasting in forestry.

Kaiser (58) has constructed an input-output table from census data to observe the flow of goods through 21 forest products industries. Kaiser concluded that the main value of this work is in the better estimates it gives of capital requirements necessary to set up these industries, and of the multiplier effects they generate. It is possible that Kaiser's figures are subject to the same sort of aggregation distortion that may apply to Ferguson's results noted above. Since Kaiser gives few details of the aggregations used. it is difficult to ascertain what degree of error may be present.

Kaiser and Dutrow (97) used a regional input-output model to observe the changes brought about in the southern United States economy as a result of the growth of the paper, ply and other wood processing industries into a market previously dominated by sawmilling. In the context of this thesis, the work is interesting for two reasons. Firstly, employment and income multipliers were calculated, the latter being similar to those described in Chapter 4 below. The second matter of interest is in the description of 'shift share' analysis (see Dunn (95)), where the performance of a regional economy is measured by comparing regional shifts in employment and value added to national averages. In some respects, this approach relates to interregional analysis as described by Isard (96), and in others, to a method for testing the performance of a regional industry against its national counterpart, introduced in Chapter 8 below.

While input-output models have been widely used at both the regional and national levels overseas, there has been little application of the technique to the comparison of land use alternatives in Australia. This thesis is mainly directed towards quantifying some of the indirect effects related to major land using industries in Australia.

To perform this task adequately, there was a need investigate some of the limitations of input-output analysis - in particular coefficient drift and aggregation distortion; hence, Chapters 5,6 and 7 are concerned with these aspects. Apart from these larger problems, a valuation anomaly in the particular model used in this study was discovered, and the procedure used in an attempt to correct this error is given in Chapter 3.

CHAPTER 3
CORRECTION OF THE 1967/68 INPUT-OUTPUT TABLE

The updated 1962/63 input-output table (Evans et al(33)) shows that in 1967/68 the pulp and paper sector purchased \$14.96m worth of input from the forestry and logging sector.

The volume of pulpwood produced in that year, according to the 1970/71 annual report of the Forestry and Timber Bureau (41) was $1,533,248m^3$. Assuming that the pulp and paper sector purchased virtually all the pulpwood output from the forestry and logging sector, then the above figures would infer that the price paid for pulp was $\$9.75/m^3$. When this is compared to the corresponding figure of $\$7.97m^3$[1] for sawlogs purchased by the sawmilling sector, it would seem that the pulpwood price is unreasonably high (when it is remembered that a reasonable pulpwood royalty figure is $\$1.69/m^3$, whereas saw log royalties range from say $\$7.00/m^3$ upwards (see figures below) The 1962/63 input-output table (CBCS (16) shows a similar relationship, indicating that an incorrect valuation was made in the original compilation, rather than the error having arisen during the iterative updating process.

Some correction of this figure is necessary, and has been carried out as outlined below.

The Non-Rural Primary Industries Bulletin[2] (CBCS (22) contains the following value of production figures (See table 99) for 1967/68;

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[1]A reasonable figure

[2]Henceforth NRPIB

	Value of Production
1. Timber sawlogs	$89,522,000
2. Hewn and other timber	27,702,000
3. Other products	551,000
Total Value	$118,769,000

If the values listed in the 1967/68 table for Current Public Expenditure and Public Investment ($11m and $18m respectively) are added to the total value figure above, the total becomes $147.8m - which is very close to the total output figure for the forestry and logging sector as given in the updated 1967/68 input output table ($148.4m) Hence it can be concluded that the NHPIB figures in fact are values for the forestry and logging sector (i.e. "milldoor" values), although this is not stated.

Having established this point, it is now necessary to estimate unit logging costs for pulpwood and sawlogs. From Humphreys (55) can be estimated the following logging costs for softwoods.

5" diam trees	$7.63/m^3$
10" " "	$6.36/m^3$
15+" " "	$4.66/m^3$

Mill door log values of hardwoods are obtainable from New South Wales Forestry Commission records, although these are not available for 1967/68. However, until the recent royalty structure alteration in mid 1973, royalties charged by the Commission did not vary significantly for the several years previous. An average royalty (before allowance) for Group B Medium Girth (i.e. 1.67 m to 2.43 m centre girth) logs (the most common selling class) in May 1972, based on averaged figures from the ten New South Wales Forestry districts, is $19.06.[3] According to the Commission's E & M Bulletin (43), logging costs for such logs are composed

3 See Appendix F

of $2.54/m^3$ for snigging, $0.93/m^3$ for loading and unloading, and $1.86/m^3$ for haulage (based on an average haul of 13 miles of A class road, 2 miles of B class road and 1 mile of C Class road). Thus, the actual royalty payable to the Commission is $13.73/m^3$.

Data cited in Chapter 8 of this thesis shows the average softwood saw log royalty to be ~~$7.63/m^3$~~ - and this closely approximates recent royalty values recorded by the Commission.

Pulp royalties vary widely from place to place, since they tend to be set by negotiation for individual areas. In the Batlow forestry sub-district, royalty for pulp is currently $1.69/m^3$ (Pers.comms. forester Batlow) It will be assumed here that this is a reasonable average figure for pulp (both hardwood and softwood), further it will be assumed that softwood and hardwood logging costs are the same, and correspond to Humphreys 5" logging costs of $7.63/m^3$.

A further assumption that has been made here is that softwood sawlogs will in fact have logging costs corresponding to Humphrey's 15+" diameter figure. Some substantiation is given to this assumption by observing the diameter distribution of saw logs from the Batlow sub-district (See Appendix E).

For 1973, the pre-war trees (which form the great majority of sawlog material) diameter distribution peaks at around 17".

Table 3.1 below summarizes the logging and royalty costs that result from the above figures and assumptions.

TABLE 3. 1

HARDWOOD AND SOFTWOOD ROYALTIES AND LOGGING COSTS

(AVERAGE)

$/m³

	Logging Cost	Royalty	Total
Softwood sawlogs	4.66	7.63	12.29
Softwood pulp	7.73	1.69	9.32
Hardwood sawlogs	5.34	13.73	19.06
Hardwood pulp	7.63	1.69	9.32

These figures can be used to calculate the contribution of softwood plantations to the total output of the sector:

The Forestry and Timber Bureau Annual Report (op cit) gives the following volumes of pulp and saw logs produced in 1967/68

991,200m^3	hardwood pulp
509,760"	softwood "
6,194,200"	hardwood sawlogs
1,161,000"	softwood "

Applying the figures given in the total column of table 2.1 to these results, it can be calculated that $10.6 m of the total output in 1967/68 was due to sales of softwood. In addition it is reasonable to assume that, in 1967/68, the bulk of investment in forestry was going to softwood planting establishment. Thus, the total investment figure of $29m can be added to the sales figure to give a total of $40m, which will be the total output from the softwood sub-sector in input output terms. This figure is 26.8% of the total sector output.

Based on these figures, the weighted average pulpwood price is approximately half of the weighted average sawlog price. Assuming that the price for sawlogs that can be calculated from the input-output table

($\$7.97/m^3$) is correct the pulp price is therefore $\$3.98/m^3$. Consequently, the \$15m transfer from the forestry and logging sector is adjusted by the factor;

3.98/9.75

and becomes \$6.21m

Hence, both the forestry and logging and the pulp and paper sectors in the 1967/68 table will need to have their total outputs reduced by \$8.21m. Balancing adjustments were made by altering the appropriate value added figures.

The correction has been applied to all the matrices based on the 1967/68 table in the remainder of this thesis.

ERRATA

A subsequent examination of the data presented in this chapter indicates that;

1. The hardwood sawlog royalty given in Table 3.1 is probably an overestimate, and should be reduced to $\$9.94/m^3$.

2. The estimated total of softwood sales of \$10,600,000 was also incorrect, and shouls be increased to \$19,000,000.

3. The assumption that all of the investment in forestry is directed towards softwoods is probably not correct. This error will, to some eetent, offset 2. above.

The net effect of these errors is that the adjustment to the \$15,000,000 transfer from Forestry and Logging to the Pulp and Paper industry is too severe at \$6,100,000 and should have been \$11,000,000.

During the early computational work in this thesis, some multipliers were calculated using the uncorrected (\$15,000,000) transfer. Subsequent re-calculation of these multipliers using the \$6,100,00 corrected transfer gave no significant difference in the multipliers calculated. Therefore, it seems safe to assume that, while the original transfer and the first correction of it are both significantly different from the final correction, the multipliers figures based on them will not be affected to any great extent.

CHAPTER 4.

MULTIPLIERS: THEIR DERIVATION AND USE IN LAND USE EVALUATION.

4.1 THE CONCEPT.

The income accelerator effect arising through a sustained autonomous rise in demand for products is commonly calculated in economic analysis, and the use of the Keynesian aggregate multiplier is equally well known. Since Keynes, the basic multiplier principle which, simply stated, has it that a given change in economic activity will initiate a chain of induced effects until equilibrium is once again attained, has been applied to more specific analysis. Two methods of quantifying these induced effects have been commonly used. They are economic base analysis, and input-output multiplier analysis.

The theoretical base of economic base analysis is the simple notion of the non-basic: basic ratio (that is, the ration of activity organised around serving local as opposed to non-local markets). Thus, employment or income multipliers are an expression of the employment or income generated within the region by all industries, divided by that generated within the basic industries.

i.e. if;

Y_b = Income generated within the region by basic industries.

Y = Total income generated within the region

then;

$$M = Y/Y_b$$

where;

M = The economic base income multiplier.

Leven et al (98) note that regional income and product accounts, and regional input-output studies are based on the same sorts of assumptions.[1]

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[1]See the reference to Billings (3) below.

They go on to say;

> "What is common to all thes explanations is that they focus almost entirely on exogenous changes in final demand - for the most part export final demand - as the moving force in regional change."

As such, they say, the method has shortcomings in that it inadequately accounts for the mobility of labour and capital, and the substitutability of labour and capital. Further, they cite an empirical study which casts some doubt on the causality of exports vis a vis their affect on growth. They admit they are unable to "write down the equations for a theory in a form that would differ very meaningfully from the general form.." of past work, but nevertheless they list some desirable improvements. These relate to the joint determination of export and growth levels, accounting for capital and labour stock changes, for interregional linkages, for govenrment and spatial effects. Some of these can probably be accounted for by imputation into a regional model of empirical information in a manner similar to that outlined in Chapter 8 of this thesis. For the rest, they will remain as necessary assumptions, ameliorated in their potential distorting effect only by more frequent and detailed observation of industry linkages and behaviour.

Economic base analysis is attractive mainly because of the limited data requirements it imposes. A standard application of this type of analysis is given by Grieg (47) , who calculated the regional income and employment multipliers resulting from the establishment of a pulpmill and a papermill within the test region. Grieg calculates the first round income multiplier (k_a) as;

$$k_a = 1 + v + \frac{E_d + \frac{V}{I} \quad w_p}{E_d \, w_d}$$

where,

E_d = Direct employment in the project

w_d = Average earnings/ direct employee

l = Increase in local value added necessary to create one private sector job

= Ratio of public service to other employees

v = Proportion of increase in income which is local value added

V = Increase in local value added by direct employees

The subsequent rounds multiplier (k_b) is calculated as;

$$k_b = \frac{1}{1 - p - c^*(1 - t^* - u)(1 - m)}$$

where;

p = Endogenous income of public sector expressed as a proportion of total regional income

c^* = Marginal propensity to consume

t^* = Marginal propensity to tax

u = Ratio of unemployment benefit to income

m = Marginal propensity to import

The regional income multiplier is therefore;

$$k_r = 1 + k_b(k_a - 1)$$

Olson and Fischer (76) used the economic base technique to estimate theimpact of resource adjustment on a regional on a regional economy. McArthur and Coppedge (66) and Reilly (100) also used the technique to examine the effects of new industries on regional income and employment.

As noted above, input-output multipliers are commonly used in regional analyses, although this is not presently so in Australia, where few regional input-output models are available. National models have been constructed in Australia, and hence it is in the national context that input-output multipliers will first be examined in this thesis.

Miernyk (73) defines the standard input-output multiplier (called a 'Type 1' multiplier as his exposition[3]) for households in an m x m interindustry system as follows;

Let;

A = Matrix of input coefficients

H = 1 x m vector of exogenous household coefficients (i.e. ratio of household services to total inputs)

D = Diagonal matrix whose leading diagonal elements are the reciprocals of the H elements.

Now, Type 1 multipliers (${}_1M$) are a 1 x m row vector such that;

$$ {}_1M = H[I - A]^{-1} D = {}_1m_j \quad (j = 1....m) \qquad (1) $$

and ${}_1m_i$ is the Type 1 multiplier for sector i.

In effect, the expression ${}_1m_i$ gives the ratio of all household requirements generated as a result of the activity of sector i to the amount of household services used directly in sector i.

Income multipliers are more commonly used than household service multipliers. Consequently, if the househol vector above is replaced in the expression with the income vector, then, discarding (for the moment) the matrix notation, expression (1) above becomes;

$$ M_i^L = L_i + T_{i(s)}^L / L_i \qquad (2) $$

[3]His 'Type 11' multiplier is applicable only when the household is endogenous to the interindustry system, since it employs a recursive process whereby the induced effects brought about by increased consumer demand which in turn is a result of increased activity, are included. Models containing an endogenous household sector are not very common.

where;

M_i^L = The income multiplier for industry i

L_i = Amount of labour input required in industry i for that industry to increase its output by one unit.

$T_{i(s)}^L$ = Amount of labour input required by all industries supplying industry i with input which just allows industry i to increase its output by one unit.

Parker (78) using eepression (3) below estimated the additional wage plus non-wage input (x) required by the whole set of industries which just allows industry i to increase its output to final demand by one unit;

$$x = \sum_{j=1}^{m} z_{ji} \, a_{vj} \qquad (3)$$

where;

x = Amount of wage plus non-wage input required.

z_{ji} = Interdependence coefficient expressing input from sector j necessary to allow sector i to deliver one unit of output to final demand.

a_{vj} = Value added per unit of output of industry j.

If labour input replaces value added in expression (3) above, then it would correspond to;

$$L_i + T_{i(s)}^L$$

in expression (2) above.

Billings (3) shows how sectoral multipliers may be summed by using weights which are a function of sector size and the labour vector. He shows that the aggregate multiplier derived after this is done for a given region is mathematically identical to the equivalent economic base multiplier, provided that its basic sectors correspond to the exogenous sectors of the input-output model. This finding is of interest when comparing economic base and input-output results.

In the definition of the input-output wage income multiplier above, the denominator was given simply as the value of labour used in the industry, as given in the labour vector. This is a commonly accepted definition of the direct effects, and has been used by Leontief (63) and others. Bradley and Gander (5) state that, when a sector increases its delivery to final demand by a given amount X, it is in fact required to increase its production by slightly more than X, because it will need to supply some of its supplying industries with more input so that they in turn can supply it with its increased requirements. This seems reasonable, and is based on the main diagonal coefficients of the $[I - A]^{-1}$ matrix always being greater than unity. Bradley and Gander's claim infers that the increase in direct labour required when a given industry increases its output to final demand by one unit will be the product of its labour coefficient (i.e. labour input (in$) ÷ total output (in $)) with the leading diagonal coefficient of $[I - A]^{-1}$ matrix.

If the 1962/63 input-output model were used to calculate multipliers the debate as to the correct definition of the direct effects would be largely academic, because that model, by convention, ignores all intraindustry trading. This causes all the main diagonal coefficients of the $[I - A]^{-1}$ matrix to fall within the range of 1.000 to 1.001. However, in the 1967/8 updating, intrasectoral trading is included, and some of the main diagonal $[I - A]^{-1}$ coefficients approach 1.100. Moreover, when the input output model is aggregated, as is done in later chapter of this thesis, some of the main diagonal coefficients will become larger still.

because any government interested in increasing the efficiency of resource allocation, within the constraints of distribution and stabilization criteria, must take into account all of the repercussion effects resulting from changes in the levels of individual industry activity. Particularly in the case of land use industries, it is important to account for the fact that very different processing chains apply to the different raw materials. If this processing factor can be included in a multiplier expression then the policy makers comparative powers will be considerably enhanced. Such an expression would largely overcome difficulties experienced when comparing different land use industries. Because of this the multiplier expression below includes some processing effect, and in this respectdiffers from conventional input-output multipliers. In fact, the multipliers developed here do not relate specifically to the form of land use in question. Rather, they express the impact, on the particular primary input being analysed, of the supplying and processing chains that surround that industry. Thus, while the multipliers given in this thesis are referenced as belonging to a particular land use industry, this convention should not be taken to literally.

The modified multiplier therefore includes the effect, on the exogenous input P of processing all the output of primary industry i to the stage of final demand.

$$M_i^{*P} = \left[T_{i(s)}^P + z_{ii}p_i + T_i^P \right] / z_{ii}p_i \qquad (4)$$

where,

M_i^{*P} = Modified multiplier of factor input P for industry i

$T_{i(s)}^P$ = The additional number of units of exogenous input P consumed in all industries which supply inputs to industry i to enable industry i to increase its output by one unit

$z_{ii}p_i$ = The additional input of exogenous input P required directly by industry i as a result of a one unit increase in output.

Bradley and Gander's argument is accepted here, and hence for the remainder of this study, direct effects will be defined as:

$$z_{ii}p_i \qquad (3)$$

where

z_{ii} = the Interdependence coefficient expressing the input necessary from industry i into itself, to allow it to deliver one unit of output to final demand.

p_i = the amount of exogenous input[2] used in industry i ÷ total output of industry i.

4.2 THE MODIFIED MULTIPLIER[3]

Conventional input-output multipliers such as those discussed above, are defined on a sectoral basis and follow through only to the stage of that sector's production.

The labour used to further process its output will not be a part of that sector's multiplier, but rather will be part of the multiplier of the processing sector. This is appropriate for multiplier analysis that deals with a wide range of industries.

However, in this analysis, the interest lies not so much in determining the direct impact of a given industry on resource but rather in quantifying the resource allocation effects generated by an industry - regardless of whether these effects are manifested in the industry itself, its suppliers, or in industries which process its output. This approach is necessary

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[2] In this work, exogenous input is a term used to describe input from any of the exogenous vectors of the input-output model. As will be seen later, this will include such vectors as labour, imports taxes, exports, capital expenditure and so on. Some (eg exports.) will have a negative sign.

[3] The original presentation of this multiplier is given in Douglas (27). A copy of this publication is supplied in the folder in the back of this thesis.

$T^{P}_{i(p)}$ = The additional input of exogenous input P required by industries processing one additional unit of industry i output.

This expression will now be defined in input-output terms, before some of the assumptions and applications of the method are discussed.

4.3 INPUT OUTPUT DEFINITION OF THE MULTIPLIER

The direct effects incorporated in the modified multipliers have already been adequately defined in equation (3).The indirect effects can be examined in two parts - "the supply side" effects and"the processing side" effects.

4.3.1 "Supply Side" Effects.

Consider the following symbolic $[I - A]^{-1}$ matrix of an input output system:-

sector No.	1......a	b......x	y......m
1	z_{11}....z_{1a}	z_{1b}....z_{1x}	z_{1y}....z_{1m}
a	z_{a1}....z_{aa}	z_{ab}....z_{ax}	z_{ay}....z_{am}
b	z_{b1}....z_{ba}	z_{bb}....z_{bx}	z_{by}....z_{bm}
x	z_{x1}....z_{xa}	z_{xb}....z_{xx}	z_{xy}....z_{xm}
y	z_{y1}....z_{ya}	z_{yb}....z_{yx}	z_{yy}....z_{ym}
m	z_{m1}....z_{ma}	z_{mb}....z_{mx}	z_{my}....z_{mm}
Factor Inputs	p_1.....p_a	p_b.....p_x	p_y.....p_m

Let a and b represent land use industries, x and y represent manufacturing industries. The lower case z's with subscripts are the $[I - A]^{-1}$ coefficients.

To the m x m $[I - A]^{-1}$ matrix has been added the raw vector of exogenous inputs P

The matrix element z_{yb} can be defined as the interdependence coefficient expressing the amount of industry m's output that is directly or indirectly required by industry b. If this coefficient is applied to the exogenous input coefficient (p_y) of industry b then the result is the amount of exogenous input P required by industry y so that it can in turn supply industry b with sufficient of its output to allow industry b to deliver one unit of output to final demand. If this process is repeated for every element of column b, and vector P (excepting the product of $z_{bb}p_b$, which is the direct effect), then the sum of all these products will be the total indirect requirement of exogenous input P generated by the production of sufficient inputs to allow industry to deliver one unit of product to final demand. Returning to the general notation used in sections 4.1 and 4.2 above, the "supply side" indirect effects can be expressed as:

$$T^P_{i(s)} = \sum_{\substack{j=1 \\ j \neq i}}^{m} z_{ji} p_j \qquad (o \leq i \leq m) \qquad (5)$$

where

z_{ji} = Interdependence coefficient expressing the necessary input from industry j into industry i to allow industry i to deliver one unit of output to final demand.

p_j = The amount of exogenous input P consumed in industry j expressed as a fraction of total output of industry j.

(other terms as defined previously)

4.3.2. "Processing side" Effects.

Calculating the amount of exogenous input P consumed by the industries processing the output of the industry for which multiplier is being calculated raises a conceptual problem. Since some of the processing if the industries will be substantially dependent on the primary industry being examined, it is perhaps questionable whether or not all the exogenous input P consumed in these industries should be attributed indirectly to the primary industry. If this assumption were accepted, then the situation would be represented by the following relationship;

Define set $J_i = \{j /$ industry j is substantially dependent on industry i$\}$

$$T_i^P(p) = \sum_{\substack{j=1 \\ j \neq i}}^{m} p_j \left[x_{jd} / X_j \right] \qquad (6)$$

where

$T_i^P(p)$ = The total amount of exogenous input P consumed in all industries substantially dependent on industry i, resulting from a one unit output for industry i to final demand.

x_{jd} = Final demand of industry j.

X_j = Total output of industry j.

(other terms as defined previously)

This relationship has some logical basis when it is reasoned that if the primary industry did not exist then the industries substantially dependent on it would also not exist. Provided that "substantially dependent" could be defined in those terms, then equation (6) might be satisfactory. However, the argument is not valid for three reasons; Firstly, a technical definition of "substantially dependent" is difficult to decide, because of the va garies of substitution and technology. Secondly, if a comparative survey of several primary industries were being undertaken (see section 4.4 of this chapter), secondary industries dependent upon more than one of the primary industries under discussion would make any classification difficult.

Thirdly, even if such definition could be made, the method is not consistent with the relationship used to evaluate indirect effects in the "supply side" case.

An approach more in keeping with the "supply side" method (and thereby input-output methodology in general) is to assume that exogenous input P is apportioned amongst the inputs into an industry, on a pro rata dollar value basis. Many of the inferences drawn in input-output analysis depend on similar "linear" arguments, and are accepted in the absence of more rigorous investigation.

As in the case of equation (6) above, a final demand factor will be included in the "processing side" term - this being necessary for the reason that, in an input-output system, for any endogenous sector i:

$$X_i = \sum_{j=1}^{m} z_{ij} x_{jd} \qquad (7)$$

which infers that, when summing effects on the output side of a given industry, only the final demand deliveries of the receiver industries need be used in accumulating totals. This automatically avoids multiple counting.

Returning to the symbolic $\left[I - A\right]^{-1}$ matrix given in sub-section 4.3.1 above, it can be seen that industry a's output is given by the coefficient z_{ax}. Using the final demand factor outlined in equation (7) above, the sum of the coefficient/exogenous input coefficient/final demand coefficient products across row a (excluding $z_{aa}\ p_a(x_{ad}/X_a)$) gives the demand for exogenous input P generated in the processing industries to process industry a's output. In general notation, this is :

$$T^P_{i(p)} = \sum_{\substack{j=1 \\ j\neq i}}^{m} z_{ij}\ p_j\left[x_{jd} / X_j\right] \qquad (8)$$

The modified multiplier introduced in section 4.2 can now be expressed in explicit input-output terms:

$$M_i^{*P} = \left[\sum_{\substack{j=1 \\ j \neq i}}^{m} z_{ji}\, p_j + z_{ii} p_i + \sum_{\substack{j=1 \\ j \neq i}}^{m} z_{ij} p_j \left[x_{jd}\ X_j \right] \right] / z_{ii} P_i \quad (9)$$

$$= \sum_{j=1}^{m} z_{ji} p_j + \sum_{\substack{j=1 \\ j \neq i}}^{m} z_{ij} p_j \left[x_{jd} / X_j \right] / z_{ii} p_i \quad (10)$$

4.3.3. Useful Relationships Based on the Modified Multiplier

One of the theoretical assumptions implicit in the multiplier expression above is that the exogenous input P, is an amorphous commodity with no internal divisions to prevent it from being perfectly mobile. However, in fact most input output models have rather broadly defined exogenous input output vectors, and there is often a need to specify the effects of given industries on the sub-groupings within exogenous input vectors. For example, it will be obvious that on exogenous input such as labour will contain many occupation classes within it. A feature of the Have mann and Krutilla work, mentioned in Chapter 1, was the ability of their model to specify the indirect effects of given industries on the various types of labour available - and this is highly desirable for planning purposes.

If exogenous input P is composed of identifiable sub-groupings, then account may be taken of this in the following manner:

Let $g_{j1}, g_{j2} \ldots\ldots g_{jn}$

be the coefficients expressing the proportions of sub-groups 1 - n that compose the total exogenous input P in industry j.

$$G_{is} = \left[\left[\sum_{\substack{j=1 \\ j \neq i}}^{m} z_{ji} p_j \, g_{js} + z_{ii} \, p_i \, g_{is} + \sum_{\substack{j=1 \\ j \neq i}}^{m} z_{ij} p_j x_{jd} g_{js} \right] / z_{ii} p_i \right] / M^{*P} \quad (11)$$

where

G_{is} = The proportion of exogenous input P generated directly and indirectly by industry i, that is classified as sub-group s.

This expression can be used to partition effects where necessary, and will be used to this effect in section 4.4 below.

It is often necessary in this type of analysis to know how much of the indirect effect exoressed in a modified multiplier is due to interindustrial activity between the sector being examined and the rest of the economy, and how much is due to the level of usage of the exogenous input in industries closely associated with the one in question. A relatively high multiplier figure for a given primary industry may, at first glance, indicate that a proportionally high degree of industrial activity is stimulated by that industry. If all industries had the same exogenous input total output ratio (for whatever exogenous input is the base of the multiplier) then this would be so. If the mean of such ratio s, weighted by the relevant individual $[I - A]^{-1}$ coefficients, was the same for each industry for which multipliers are calculated, then the statement would hold. The following expression can be used to calculate such a mean, thus enabling this effect to be quantified, so that the real stimulative effect of an industry can be seen:

let:

$$m_i = \sum_{\substack{j=1 \\ j\neq i}}^{m} \left[z_{ji}\ p_j / \sum_{\substack{j=1 \\ j\neq i}}^{m} z_{ji} \right] \qquad (12)$$

and:

$$n_i = \sum_{\substack{j=1 \\ j\neq i}}^{m} \left[z_{ij}\ p_j / \sum_{\substack{j=1 \\ j\neq i}}^{m} z_{ij} \right] \qquad (13)$$

now

$$PM_i = \left[m_i T^P_{i(s)} + n_i T^P_{i(P)} \right] \Big/ \left[T^P_{i(s)} + T^P_{i(P)} \right] \qquad (14)$$

where,

PM_i = The sum of the exogenous input P /total output vector, weighted by their significance to industry i.

For brevity, this value will henceforth be referred to as the inverse-weighted mean (of exogenous input coefficients)

4.4 MODIFIED MULTIPLIER ANALYSIS OF FOUR AUSTRALIAN LAND USE INDUSTRIES

The application of the above methods is best examined in the light of a multiplier analysis of some major Australian land use industries. Those selected in this case are; the wool industry,[4] the wheat industry, the meat cattle industry and the forestry industry

The first task in such an analysis is to decide what multipliers are relevant. This will depend on the aims of the economic investigation, and will be constrained by what factor input vectors are included or can be calculated from exogenous sources in the model being used. In the 1967/69 model (33) which will be used here, the factor input vectors of interest are:-

1. Commodity Taxes less subsidies on inputs
2. Value added
3. Indirect Taxes.

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4 See Douglas (27)

The labour figures used in this were in fact an adjusted version of those derived from the input output table . The adjustment was necessary because those labour figures excluded owner-operator labour in the agricultural industries. To include owner-operator labour, it was necessary to use other data sources. A major problem arose because those supplementary sources, such as the Bureau of Agricultural Economics bulletins and the Bureau of Census and Statistics publications classify the Agricultural industries differently to the Input-Output Table. Where more than one commodity was produced on a farm, the problem increased because the input-output table is set out on an industry/commodity basis, and allows only one commodity to be produced by one industry. By contrast, BAE data contains such industry classifications as the "Wheat-Sheep Zone." Hence it was necessary to sort the data into industry groups. The owner-operator labour figures were then derived by allocating that labour from the multiple product farms to the relevant commodity groups on a pro rata basis. The difference that such an adjustment makes can be seen by comparing rows 1 and 2 in table 4.1.

TABLE 4.1
LABOUR INPUT OUTPUT FIGURES FOR THE FOUR LAND USING INDUSTRIES

Labour coefficient*	WOOL	WHEAT	MEAT CATTLE	FORESTRY
as per exogenous data	.18	.035	.13	.32
Labour coefficient adjusted to include owner operator labour	.35	.13	.33	.32

* Labour coefficient for industry i = (Labour input into industry i (in $) / Total output of industry i (in $)

In addition, the final demand matrix of this model includes exports and competing imports as individual columns, so multipliers can be calculated based on these. The treatment of competing imports as a negative final demand in this model is preferable to the 1962/63 model which, in its preliminary form,[5] allocates imports indirectly - that is, to the sectors where they would have been produced had they been produced in Australia. Such an allocation has uses in some analysis, but renders multiplier analysis of imports difficult to interpret.

Value Added is a general term which covers too broad a range for meaningful multipliers. One of the items included in this vector is wages, and this factor is of greater interest in multiplier analysis than value added. The wage vector was derived for this model from other sources,[6] and the appropriate correction made to the value added vector.

Five multipliers can now be calculated for this model;

1. The wage income multiplier
2. The indirect taxes[7] multiplier
3. The commodity taxes[8] multiplier
4. The imports multiplier
5. The exports multiplier

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5 Which was the only form of this model available at the time of writing.

6 See Appendix 1.

7 Indirect taxes includes such items as rates, payroll tax, licensing fees, land tax, stamp duty, fines, excise.

8 Commodity taxes includes fuel taxes, export charges, subsidy effect.

The forestry figure has remained unchanged by the adjustment. This is because this industry is virtually completely controlled by either government or large companies in Australia, and therefore has no owner-operator labour. The adjustment makes all the four industries comparable in regard to labour input.

It may be argued that a similar adjustment should be carried out on all the industries in the input-output table. This is in fact unnecessary; a perusal of the Manufacturing Industries Bulletins (21) shows that owner operators account for only 2.5% of the labour performed in non-agricultural industries. Even in the sawmilling industry, which is generally regarded as having a comparatively high owner-operator component, the figure reaches only 5%.

Table 4.2 contains, in column 2, the modified labour multipliers for the four industries, as per expression (9). A more useful figure for comparative purposes is obtained by expressing the total exogenous input consumption generated by the given industry, as a fraction of that industry's output. Utilizing the definition of p_i given in the expression (3);

$$p_i = \frac{P_i}{X_i}$$

where P_i = The total amount of exogenous input P (in$) used in industry i at the existing level of output.

now, $$XP_i = \left[\left[T^P_{i(s)} + z_{ii}p_i + T^P_{i(p)}\right] P_i\right] / X_i \qquad (15)$$

where XP_i = The total demand for exogenous input P generated by industry i, expressed as a fraction of the output of industry i.

Such a figure is more readily comparable with equivalent values for other industries, since it allows the analyst to see the total demand generated for the exogenous input, by a one unit input into the industry concerned. These values will henceforth be referred to as multiplier/output ratios. The labour figures calculated according to this relationship are given in column 3 of Table 4.2.

Column 4 of Table 4.2 contains the inverse weighted means of exogenous input (wage income in this case) coefficients .

TABLE 4.2

WAGE INCOME EFFECTS OF THE FOUR LAND USING INDUSTRIES

INDUSTRY	LABOUR MULTIPLIER (Equation (10))	MULTIPLIER OUTPUT RATIO (Equation (15))	WEIGHTED MEANS OF LABOUR COEFFICIENTS (Equation (14))
(1)	(2)	(3)	(4)
WOOL	1.65	.58	.32
WHEAT	2.69	.35	.25
MEAT CATTLE	1.87	.62	.30
FORESTRY	2.07	.66	.28

In subsection 4.3.3 the division of an exogenous input vector was discussed. Of the multipliers being discussed here, the wage income multiplier is the one most obviously in need of some kind of partition into smaller units. In this case, it was decided to use the classification developed by the Tariff Board (85), which places the several hundred occupations listed in the Classification and Classified List of Occupations (19) into the following five major skill groups[9].

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[9] For more details, see Appendix B

1. Professional, technical and related workers.
2. Clerical and related workers
3. Sales workers
4. Unskilled workers
5. Unclassified.

Table 4.3 gives the proportions of each of the five skilled groups employed directly in the major land use industries in Australia.

TABLE 4.3

SKILL GROUP COEFFICIENTS FOR THE MAJOR AUSTRALIAN LAND USING INDUSTRIES

INDUSTRY	SKILL GROUPS				
	1	11	111	1V	V
WOOL	.00	.69	.31	.00	.00
WHEAT	.00	.78	.22	.00	.00
OTHER GRAINS	.00	.66	.33	.01	.00
MEAT CATTLE	.00	.61	.39	.00	.00
MILK CATTLE AND PIGS	.00	.71	.29	.00	.00
POULTRY	.00	.58	.42	.00	.00
OTHER CROPS	.00	.66	.34	.00	.00
FORESTRY	.03	.37	.59	.01	.00

Classification problems were again apparent in compiling these figures. The skill group classifcation used is compatible with the 67/68 input-output model in the secondary and tertiary divisions, but groups all rural industries under the single heading of Agriculture. To rectify this, it was necessary to inspect detailed Bureau of Census and Statistics records of occupational employment in the various industries. These figures were then adjusted to be compatible with the input-output classification of industries by using a procedure analogous to that described in the discussion of allocation of owner-operator labour above.

Table 4.4 shows the direct and indirect effects of the four industries being examined on the distribution of labour through the skill group.

TABLE 4.4

DIRECT AND INDIRECT EFFECTS OF THE FOUR LAND USING INDUSTRIES ON SKILL GROUPS

Industry	Skill Group				
	1	11	111	1V	V
WOOL	.0096	.5594	.3805	.0503	.0001
WHEAT	.0235	.4345	.4144	.1273	.0003
MEAT CATTLE	.0218	.3928	.4642	.1209	.0002
FORESTRY	.0313	.2348	.6134	.1203	.0002

The multiplier/output ratios for the indirect tax, commodity tax, imports and exports multipliers are given for the four industries in Table 4.5

TABLE 4.5

MULTIPLIER OUTPUT RATIOS FOR THE FOUR LAND USING INDUSTRIES

INDUSTRIES	MULTIPLIERS UPON WHICH RATIOS ARE BASED			
	Commodity Taxes	Indirect Taxes	Imports	Exports
WOOL	.0028	.1180	.216	1.252
WHEAT	.0116	.0507	.234	1.183
MEAT CATTLE	.0028	.0558	.162	.397
FORESTRY	.0458	.0565	.108	.093

Before progressing to conclusions, some limitations of the analysis must be discussed. If the results are to have practical application, then it must be able to be shown that the multipliers are not likely to have changed significantly over time. In chapters, 5, 6 and 7 aspects of coefficient drift over time in input-output models are investigated in some detail. It is sufficient to state here that evidence will be given in those chapters to suggest that the 1962/63 model (upon which the 1967/68 model is based) is of reasonably high quality, and that multipliers remain more stable over time than individual input coefficients.

A second more specific limitation is that the particular figures used here are broad national averages. In their present form, they cannot be applied to evaluating specific projects based on the industries examined. In chapter 8, attention is given to imputing more specific industry figures into the general model.

Even given the above reservations, some specific conclusions can be drawn from the results given above. In terms of employment generation, the high multiplier/output figure for forestry, and to a slightly lesser extent the meat cattle industry indicates that these industries have a greater influence per dollar of output on the labour market than the other two industries. Moreover, this argument can be extended here to the claim that the forestry and meat cattle industries stimulate a higher degree of industrial activity in the economy than the wool and wheat industries. This claim can be made on the basis of wage income multiplier/output figures here, because the weighted means of wage income coefficients (Column4, Table4.2) for the four industries do not vary over a great range.

It was to be expected that forestry would show a higher commodity tax multiplier than the other industries, because many of the agricultural subsidies and bounties will affect this multiplier. A surprisingly high indirect tax multiplier resulted for the wool industry, and if the commodity tax and indirect tax multiplier are combined, the wool industry has the highest multiplier, indicating that this industry generates more of this type of taxation revenue than the other industries, per dollar of output.

Not surprisingly, the export multiplier/output ratios reveal a highly stimulative capacity in the wheat and wool industries in the export field, with the other industries following in the order that would be expected, given the nature of each. The high export income generation from the wheat and wool industries is offset to some extent by a high import multiplier/output ratio from these industries. The import and export multipliers alone do not reveal the total effects of these industries on foreign exchange reserves. A third factor, the cost of replacing the output of the industry consumed locally with imported material, must also be taken into account. The use of a multiplier to express this import saving effect is not conceptually appealing. For instance, were all the industries which use the output of the forestry industry to replace the local forestry raw material with imports, then the only additional effect of that on foreign exchange reserves would be the cost of the imported material.

If is is assumed, for the moment, that the import price: local price ratio for the four commodities produced by the four land use industries being examined here is 1:1 then according to the reasoning above, the import saving effects of these industries would be the sum of their intermediate deliveries plus their deliveries to personal consumption.

TABLE 4.6

INTERMEDIATE DELIVERIES PLUS PERSONAL CONSUMPTION DELIVERIES OF THE FOUR LAND USE INDUSTRIES

Industry	Expressed in $m	Expressed as % of output
WOOL	302.7	36.0
WHEAT	87.7	26.0
MEAT CATTLE	442.4	87.0
FORESTRY	123.0	83.0

As would be expected, the high-export industries have a lower import-saving potential than do the low export industries.

The net foreign exchange effect for one of these industries can now be calculated by summing its export generation and import saving effects, and subtracting from this the import generation effect. In Table 4.7 the results of such calculations are given expressed in multiplier form.

TABLE 4.7

NET FOREIGN EXCHANGE EFFECTS OF THE FOUR LAND USING INDUSTRIES

Industry	Net Foreign Exchange Effect
WOOL	1.40
WHEAT	1.21
MEAT CATTLE	1.11
FORESTRY	.76

Obviously, these figures cannot be regarded as a totally accurate representation of the foreign exchange effects of these industries. The influences of tariffs and subsidies have been ignored. The technological implications of a transition to the use of imports have also been disregarded. Nevertheless, given the high order of difference between forestry and the other industries, it is reasonable to suggest that a reduction in production of forestry material would have a relatively lower effect on foreign exchange reserves than would a comparable reduction in the other industries. The inference that may be drawn from this is that the use of import-saving criteria as arguments in favour of investment in forestry (see Jacobs (56)) is dubious, unless rather radical assumptions about relative shifts in local and overseas prices are shown to be acceptable.

It is hoped that the above analysis has shown the potential that this methodology has in specifying effects, and ranking industries according to those specifications. The multipliers above relate to some, although not all, of the important factors which must be considered in public investment analysis. The limitations of the analysis at this stage mainly relate to the lack of data (both of the specific sort referred to above, and of existent or derivable vectors in the model upon which to base multipliers), and the generality of the model. In chapter 8, some experimentation with imputation of more specific industry data is undertaken, and this approach, along with the development of regional input-output models where necessary, should help to overcome the latter limitation.

In conclusion, it can be stated that whether it is desired to maximise a given variable, or to use it as a constraint in a project valuation, it is clear that all the effects on that variable emanating from the project must be quantified. Nomination of upper and/or lower allowable limits for a variable in such an analysis must be accompanied by an investigation which includes indirect as well as direct effects.

Further use will be made of the figures given in this chapter in chapter 8. Attention will now be given to the two major problems in the use of input-output models, coefficient drift over time, and aggregation distortion, and how these may be resolved in the Australian model.

CHAPTER 5

THEORETICAL ASPECTS OF AGGREGATING INPUT-OUTPUT MATRICES

5.1. REASONS FOR AGGREGATING MATRICES

In chapter 4, it was shown that the use of a quite large input-output model is possible, and yields useful results. On the surface, with the computational equipment now available, it may seem that aggregation[1] of input-output models is no longer necessary. Certainly, if the quite considerable cost of manipulating large matrix systems on the computer is ignored, the need for smaller systems has been somewhat reduced. There remain quite important reasons, however, for the consolidation of input-output models.

Most obviously, the comprehension and interpretation of results yielded by the model is simplified if the number of sectors is reduced. At some stage, the results need to be expressed in reasonably explicit yet brief terms, and this can prove quite difficult with a large matrix system.

A second reason for consolidation of matrix systems is in data collection. As will be seen from chapter 8, some uses of input-output analysis are dependent on data collected from exogenous sources. When these sources are not conformable with the input-output table, it is of considerable advantage if the headings under which information is required are few and well-defined. Moreover, the ability to consolidate sectors in a model

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[1] Here defined as the consolidation of two or more sectors into one.

with little distortion when a comparison with data under a different classification is required. In chapter 7 a comparison between the 1958/59 Input-Output Tables and the 1962/63 table was made possible due to the fact that some sectors of the larger matrix were able to be consolidated into sectors more or less comparable with some in the smaller system with little distortion.

Perhaps a more nebulous rationale for aggregation is in the assistance it may give in understanding the nature of the matrix system being used. The results given in the next chapter, for example, show to what level the various matrices used may be aggregated and in so doing give an idea as to the quality of the initial aggregation[2].

5.2 THEORETICAL CRITERIA FOR AGGREGATION

Hatanaka (50) showed that, for a reduction of an m x m system to a smaller n x n system, where C is a consolidation matrix which completely defines the consolidation;

$$\left[I^* - A^*\right] C X = C \left[I - A\right] X$$

where,

A^* = The n x n consolidated matrix of input coefficients.

I^* = The identity matrix of order n x n

I = The identity matrix of order m x m

X = The vector of outputs of order m.

then;

$$A^*C = CA$$

2 Leontief (63), among others, has pointed out that a poor initial aggregation is very much a possibility in input-output analysis.

Hatanaka admits that this relationship will rarely result in practice since it requires that;

a. The original sectors that are combined must have no intrarelationships

b. The original sectors that are combined must have identical cost structures.

From this theoretical base, Malinvaud (70) formalized fixed-weight aggregation from the point of view of preservation of repercussion effects. F.M. Fisher (38) showed that, except where the functions involved in the aggregation procedure possess certain unusual properties, the formal conditions for aggregation are not easily evaded. Morishima and Seton (75) provide an analysis of the distortion effects that can result from aggregation.

Malinvaud has seen the aggregation problem as being one of preserving the standard input-output relationship;

$$(I^* - A^*)\ CX \ = \ CY$$

(terms as defined previously)

in the aggregated system. Since the bulk of interest to date has been centred around the model's ability to quantify indirect effects via this relationship, the preservation of the relationship as a criterion of aggregation is reasonable.

However, as will be seen in chapter 6, there are occasions when the model is required for various other purposes - in that case the quantification of multiplier effects. It is of interest therefore, to examine the necessary conditions for preservation of multiplier effects when aggregating input-output matrices.

5.3 PRESERVING MULTIPLIER EFFECTS[3]

$m_i = \sum_j z_{ji} \frac{P_j}{x_j} / \frac{P_i}{x_i}$ is the generalised formula of an input output multiplier where

m_i is the multiplier for industry i

z_{ji} is the j-i-th coefficient of $(I-A)^{-1}$

P_j is the direct input in \$ from factor P to industry j

x_i is the total output (or input) of industry i.

Define $q_i = P_i/x_i$, $s_i = m_i q_i$ and $U_i = s_i x_i$. Then q_i is the input from factor P to industry i as a proportion of total input to industry i, s_i is the total direct and indirect factor input to industry i as a proportion of total input to industry i and u_i is to total direct and indirect factor input to industry i in \$. The multiplier may now be written as

$$m_i = \sum_j z_{ji} \, q_j/q_i$$

$$\therefore \quad m_i q_i = \sum_j z_{ji} \, q_j$$

i.e. $$s_i = \sum_j z_{ji} \, q_j \qquad (1)$$

Equation (1) in matrix form is $S = (I-A)^{-IT} Q$

$$\therefore \quad S^T = Q^T (I-A)^{-1}$$

$$\therefore \quad S^T (I-A) = Q^T$$

$$\therefore \quad (I-A)^T S = Q$$

$$\therefore \quad (I^T - A^T) S = Q$$

$$\therefore \quad (I-A^T) S = Q \qquad (2)$$

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[3] The proof given in this section is adapted from a paper in preparation by Johnson and Douglas (57)

An aggregation which preserves multiplier effects must comply with the following conditions:

(a) The direct factor input and total direct and indirect factor input to an industry which is not aggregated with any other industry must remain unchanged.

(b) The direct factor input to a sector consisting of several aggregate industries must be the sum of the direct factor inputs to those industries.

(c) The total direct and indirect factor input to a sector consisting of several aggregated industries must be the sum of the total direct and indirect factor inputs to those industries.

(d) The relationship between total direct and indirect factor inputs as a proportion of total input and direct factor input as a proportion of total input as expressed in equation (2) must be preserved.

(e) The total output of an industry which is not aggregated must remain unchanged.

(f) The total output of a sector consisting of several aggregated industries must be the sum of the total outputs of those industries.

If we define C to be a matrix, called the consolidation matrix, by;

$$C_{ij} = \begin{cases} 1; & \text{industry } j \text{ is included in sector } i \text{ of the aggregated model} \\ o, & \text{otherwise} \end{cases}$$

And if we denote all vectors, matrices and elements of vectors and matrices in the aggregated model by a * superscript, then requirement a, b and c may be written as;

$$U^* = CU \text{ and } P^* = CP \qquad (3)$$

Requirement (d) may be written as;

$$Q^* = (I^* - A^{*T})S^* \qquad (4)$$

Requirement (e) may be written as;

$$X^* = CX \qquad (5)$$

Furthermore by defining B to be a diagonal matrix of total outputs relationships between P and Q can be established,

Namely $P = BQ$ and $Q = B^{-1}P$ (6)

Also the relationship between U and S can be established.

Namely $U = BS$ and $S = B^{-1}U$ (7)

Hence $Q^* = B^{*-1}P^* = B^{*-1}CP = B^{*-1}CBQ$ (8)

and $S^* = B^{*-1}U = B^{*-1}CU = B^{*-1}CBU$ (9)

The i-jth element of $B^{*-1}CB$ is $\sum_k (B^{*-1}C)_{ik} b_{hj}$

$$= (B^{*-1}C)_{ij}\, b_{jj}$$

$$= (\sum_t b^{*-1}_{it}\, C_{tj})\, b_{jj}$$

$$= b^{*-1}_{jj}\, C_{ij}\, b_{jj}$$

$$= x_j C_{ij}/x^*_i$$

Define a matrix C* by;

$$C^*_{ij} = \begin{cases} \dfrac{x_i}{x^*_j} ; & \text{industry } i \text{ is in sector } j \text{ of aggregated model} \\ 0 ; & \text{otherwise} \end{cases}$$

Then $C^*_{ij} = x_i C_{ji}/x^*_j$

$\therefore$ $B^{*-1}CB = C^{*T}$ and equations (8) and (9) become (10)

$$Q^* = C^{*T}Q \qquad (11)$$

and $$S^* = C^{*T}S \qquad (12)$$

From (3) $U^* = CU$ it follows that if sector 1 in the aggregated model is the aggregation of industries 1, 2 and 3 in the disaggregated model then $U^*_1 = U_1+U_2+U_3$.

Hence $U_1 = \alpha_1 U_1^*$ and $U_3 = \alpha_3 U_1^*$ where $\alpha_1, +\alpha_2+\alpha_3 = 1$

This can be written in the form $U = HU^*$ where $h_{ij} + C_{ji} U_i/U_j^*$

Hence $U = HU^* = HCU$ and $U^* = CU^*$ must be satisfied by H.

$$(CH)_{ij} = \sum_t C_{it}h_{tj} = \sum_t C_{it} C_{jt} U_t/U^*j$$

But $C_{it}C_{jt} = o$ if $i \neq j$ and so

$$(CH)_{ij} = {}_t \; T_{it} U_t/U^*_j \quad (\text{or } o \text{ if } i \neq j)$$

$$= U^*_j/U^*_j \quad (\text{or } o \text{ if } i \neq j)$$

$$= I \quad (\text{or } o \text{ if } i \neq j)$$

$\therefore$ $CH = I^*$ hence $CHU^* = I^*U^* = U^*$ (13)

$$(HC_{ij} = \sum_t C_{ti} U_{i/_{U^*_t}} C_{tj}$$

$$= \begin{cases} U_i/U_k^*; & \text{industry } i \text{ and industry } j \text{ are in sector } k \\ o; & \text{otherwise} \end{cases}$$

$$\therefore \quad (HCU)_i \; \Sigma = {}_t \; (HC)_{it} \; U_t$$

$$= U_i \quad U^*_k/U^*_k = U_i$$

$\therefore$ HCU = U Q.E.D.

$\therefore$ $U = HU^*$ and $S = B^{-1}U = B^{-1}HU^* = B^{-1}HB^*S^*$

But $(B^{-1}HB^*)_{ij} = \sum_t (B^{-1}H)_{it}\, b^*_{tj}$

$$= (B^{-1}H)_{ij}\, x^*_j$$

$$= \sum_k b^{-1}_{ik} h_{kj}\, x^*_j$$

$$= \frac{1}{x_i}\, h_{ij}\, x^*_j$$

$$= x^*_j/x_i\, C_{ji} U_i/U^*_j$$

$$= x^*_j/U^*_j\, \frac{U_j}{x_i}\, C_{ji}$$

$$= \frac{1}{s^*_j}\, S_i\, C_{ji}$$

Define C^*_s by $C^*_{sij} = C_{ij}\, s_j/s_i$

Then $C^{*T}_s = B^{-1}HB^*$ (14)

and $S = C^{*T}_s S^*$ (15)

Substituting (15) for s in (2) yields

$$Q = (I - A^T)\, C^{*T}_s S^* \quad (16)$$

Substituting (16) for Q in (11) yields

$$Q^* = C^{*T}\, (I - A^T)\, C^{*T}_s\, S^* \quad (17)$$

Substituting (17) for Q* in (4) yields

$$C^{*T}\, (I - A^T)\, C^{*T}_j\, S^* = (I^* - A^{*T})S^*$$

$\therefore$ $(C^{*T}(I - A^T)\, C^{*T}_s - (I^* - A^{*T})\,)\, S^* = o$

$\therefore$ $(C^{*T} I C^{*T}_j - C^{*T} A^T C^{*T}_j - I^* + A^{*T}) S^* = o$ (18)

But $C^{*T}C^{*}_{j}{}^{T} = B^{*-1}(BB^{-1}HB^{*}$ from equations (10) and (14)

$= B^{*-1}CHB^{*}$

$= B^{*-1}I^{*}B^{*}$ from equation (13)

$= I^{*}$

$\therefore$ (18) becomes

$$(A^{*T}-C^{*T}A^{T}C^{*}_{s}{}^{T})\ S^{*} = o$$

Since $S^{*}\neq o$, $(A^{*T}-C^{*T}A^{T}C^{*}_{j}{}^{T})$ has an eigen value of zero with corr-esponding eigen vector. θ is any scalar or real number.

The triv ial solution is $A^{*T} = C^{*T}A^{T}C^{*}_{s}{}^{T}$

$$\text{or } A^{*} = C^{*}_{s}\,AC \qquad (19)$$

Let F denote the flow matrix

Then $f_{ij} = a_{ij}x_{j}$ $\therefore F = AB$

Let J be a vector of ones $j_{1}=j_{2}--- = j_{n} = 1$

Then by definition of flow matrix and total output $x = FJ$

and from the definition of B and J, $X = BJ$

and $X^{*} = F^{*}J^{*} = A^{*}B^{*}J^{*}$

$= C^{*}_{s}\,AC^{*}\,B^{*}\,J^{*}$

$$(C^{*}B^{*})_{ij} = \sum_{t} C^{*}_{it}\, b^{*}_{tj} \qquad (i=1,--,n;\ j=1,--m)$$

$$= C^{*}_{ij}\, x^{*}_{j}$$

$$= \frac{x_{i}}{x^{*}_{j}}\, C_{ji}\, x^{*}_{j}$$

$$= x_{i}\, C_{ji}$$

$$\therefore (C^{*}B^{*}J^{*})_{i} = \sum_{t} (C^{*}B^{*})_{it}\, j_{t} \qquad (i=1,--,n)$$

$$= \sum_{t} x_{i}C_{ti}\, j_{t}$$

$= x_i \sum_t C_{ti}$

$= x_i$ since each column of C has exactly one "1" as each industry in the disaggregated model must appear in exactly one sector of the aggregated model.

$\therefore \; C^*B^*J^* = X = BJ$

$\therefore \; X^* = C^*_s \, ABJ = C^*_s \, FJ = C^*_s X$

But $X^* = CX \; \therefore \; CX = C^*_s X$

$\therefore \; (C - C^*_s) X = o$

This has the trivial solution $C^*_s = C$

$\therefore \; \dfrac{s_j \, C_{ij}}{s^*_i} = C_{ij}$

$\therefore \; s_j / s^*_i = 1$ if industry j is in sector i

$\therefore$ If industries i and k are to be aggregated, $s_i = s_k = s^*_j$ where j is the sector containing industries i and k.

If $s_i = s_k$ then $\dfrac{U_i}{x_i} = \dfrac{U_k}{x_k} \quad \therefore \; U_i = \dfrac{x_i}{x_k} \; U_k$

and $\quad s^*_{s_j} = \dfrac{U^*_j}{x^*_j} = \dfrac{U_i + U_k}{x_i + x_k} = \dfrac{\dfrac{x_i U_k}{x_k} + k}{x_1 + x_k}$

$= \dfrac{U_k}{x_k}$

$= s_k$

Hence if only industries having equal s values are aggregated using A*=C AC* multiplier effects are preserved.

CAC* is equivalent to aggregating the flow matrix, hence Hatanaka's conditions apply.

If one wishes to aggregate an input/output matrix without observing the condition above then $C^*_s \neq C$ and aggregation of the flow matrix will only preserve multiplier effects if (CAC*-C*) has an eigen value of zero with corresponding eigen vector ΘS* for any scalor Θ or Θ = 1.

It seems reasonable to suggest from the above proof that the modified multiplier proposed in chapter 3 would require the matrix to be aggregated according to the same conditions for effects to be preserved. Clearly the Hatanaka conditions are unlikely to be met completely in practice, and it is appropriate, therefore, to review some of the approximations and alternatives that have been devised to overcome this difficulty.

5.4 APPROXIMATION METHODS OF AGGREGATION

Yamada (93) claims that aggregation for invariability of repercussions is extremely difficult[4], and suggests that instead, aggregation to minimize the variance of input coefficients should be tried. The particular nature of the problem of approximating an entire matrix to meet with certain conditions has led to some experimentation with optimization methods. Both McCarthy (67) and W. Fisher (39) have tried this approach, with some success.

4 Although the results given in chapter 6 suggest that reasonable approximation of this requirement is possible, provided that certain practical rules are followed

Leontief (61) has provided an interesting alternative to aggregation, and a brief exposition of this method is given below;

Suppose that industries in the economy are divided into two groups. Group 1 industries will be those of direct interest in the analysis, and will be assumed to supply all the necessary inputs to a group 2 industry so that that industry can make its deliveries to the group 1 industry.

Let, A_{11} be the square matrix representing the inter-industry flows between group 2 industries.

A_{22} be the square matrix representing the interindustry flows between group 2 industries.

A_{22} be the rectangular matrix representing the direct requirements of group 2 industries for group 1 products.

A_{12} be the rectangular matrix representing the direct requirements of group 1 industries for group 2 products.

X_1 be the vector of total outputs of group 1 industries

X_2 be the vector of total outputs of group 2 industries.

Y_1 be the vector of final demands of group 2 industries.

Now, the original expression;

$$[I - A]\ X = Y$$

is represented by;

$$\begin{bmatrix} (1 - A_{11}) & -A_{12} \\ -A_{21} & (1 - A_{22}) \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} = \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix}$$

Let
$$\begin{bmatrix} X_1 \\ X_2 \end{bmatrix} = \begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{bmatrix} \begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix}$$

Now,
$$X_1 = B_{11}Y_1 + B_{12}\, Y_2$$
$$X_2 = B_{21}\, Y_1 + B_{22}Y_2$$

Premultiplying both sides by B_{11}^{-1} gives;

$$B_{11}^{-1}\, X_1 = Y_1 + B_{11}^{-1}B_{12}\, Y_2$$

Let
$$A^*_{11} = 1 - B_{11},\; Y^*_1 = Y_1 = B_{11}^{-1}\, B12\, Y_2$$

Now
$$\left[I - A^*_{11}\right] X_1 = Y^*_1$$

Hence,
$$X_1 = \left[I - A_{11}^*\right]^{-1}\, Y_1$$

and
$$A^*_{11} = A_{11} + A_{12}\left[I - A_{22}\right]^{-1} A_{21}$$

A_{11}^* is the structural matrix of the economy originally described by A. The individual coefficients will implicitly reflect the input of the industries eliminated (group 2).

This method is appealing, since it eliminates the need for the use of weights or other arbitrary constants in the consolidation procedure. The empirical results which accompany the work are more designed to show that the method produces a feasible result, rather than to quantify the amount of distortion present, but they serve to indicate that the method warrants further investigation.

Charnes and Cooper (14) have proposed a method for approximating the distortion-free matrix by use of a technique based on the minimization of the maximum of column sum norms of the aggregated set.

The writers begin their exposition by claiming that the relationship

$$(I^* - A^1)CX + CY$$

will not in general hold[5], when

A^1 = the input coefficient matrix which results when the original flow matrix is consolidated, and the coefficient matrix is produced by the normal division procedure. In fact, following Malinvaud (op cit), and the multiplier effects proof given in section 5.3 above, it seems clear that in theory a straight aggregation of the flow matrix <u>will</u> produce a better approximation of the required aggregated matrix than any other method. However, Charnes and Cooper apparently do not agree, and suggest instead the following procedure;

Using the previous notation, define

$$CA = B$$

Now define

$$D = CB - A^*C$$

The object now being to minimize D, so that the closest approximation to A* is achieved. Since Leontief systems are linear, it is reasoned that the closeness of linear transformations is a suitable criterion to use to this end. Charnes and Cooper

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[5] And in exact terms, this is true.

show that the column sum norm at D is;

$$N_c(D) = \max. N_c(D_j)$$

where

D_j is the jth column of D.

Now, since

$$N_c(D_j) = \max. \sum_{i=1}^{m} b_{ik} - c_{ij}$$

where the b_{ik} are elements of B and the c_{ij} elements of C, it is possible to determine m values for c_{ij}, i = 1, m separately for each j in order to minimize $N_c(D_j)$. This in fact requires the solution of m linear programming problems, which can be stated in the form;

Min. λ

subject to

$$|b_{ik} - c_{ij}| = \lambda_{ik}$$

$$\sum_{i=1}^{m} \lambda_{ik} = \lambda$$

This method lends itself to expression as a computer algorithm, and hence it was possible to test its performance empirically in relatively large systems. The results of such testing, compared with those produced by straight aggregation of the flow matrix are given in the next chapter. It is difficult to relate Charnes and Coopers procedure to the theoretical requirements for aggregation discussed earlier in this chapter, and in view of this and the poor practical results gained when using the algorithm based on their analysis, it seems reasonable to suggest that their method has little application to the problem of aggregation of input output systems.

CHAPTER 6

AGGREGATION IN AUSTRALIAN INPUT OUTPUT TABLES

6.1. INTRODUCTION

In the previous chapter , it was shown that there exists the possibility of aggregating matrices to preserve both repercussion and multiplier effects. In this chapter, some empirical aspects of matrix aggregation will be examined with a view to developing guidelines and general conclusions related to the methods and mechanics of aggregation in large matrix systems.

6.2. COMBINATION OF SECTORS

The practice of aggregating input-output systems is a two stage procedure. Firstly, the specific combination of sectors to be aggregated must be decided on, and secondly, the method to be used to produce the reduced model must be selected. Both of these stages are covered in the theoretical requirements outlined in chapter 5. In theory, the combination of sectors, should, as closely as possible, satisfy the Hatanaka conditions. Once the combination is selected, the new flow matrix is produced by weighting the combined sectors according to the relative size of their outputs. This chapter will examine the application of these requirements in practice.

6.2.1 Combining Sectors in the 1967/68 Model

The aggregation used in this section may be defined as "favoured sector" combinations, in that they have as a primary aim the preservation of multiplier and repercussion effects in one sector in particular - in this case the forestry and logging sector. Adoption of this notion allows more consolidation than a general purpose aggregation, because sectors not closely related to the favoured sector can be aggregated more heavily (since the distortion effects of so doing will not affect the specific purpose of the model). The problem now becomes one of deciding which sectors are important in relation to the favoured sector (and any combination of these will have to be made in reasonably close approximation of the Hatanaka conditions), and which are unimportant (and these can be combined without too much regard to their similarities and differences). There will of course be a grading of sectors between these extremes. Three alternative methods for determining this grading are presented below;

1. Aggregation "by eye". This is an ad hoc procedure where sectors are ranked in terms of their importance to the favoured sector simply on the basis of the level of their flow matrix interaction with it.

2. Partial round-by-round combination. Following the round-by-round procedure outlined in chapter 2, this method allows some account of the indirect relationships between the various sectors to be taken into account. It is therefore preferable to method 1 above.

3. $(I-A)^{-1}$ combination. When the Leontief inverse of the input output system in question is available, this method seems the most logical. The degree to which sectors are combined in violation of the Hatanaka conditions is determined by their direct <u>and indirect</u> relationship with the favoured sector - this relationship can of course be seen directly from the inverse matrix.

Eight of the nine aggregations of the 1967/68 model were based on one or other of these methods - and the details of the sectoral combinations used are given in Appendix C. The ninth combination is a small (12 sector) "nonsense" aggregation.

6.2.2. Testing Sectors

Multiplier and repercussion effects for sectors other than the forestry and logging sector are given in the results. The intention of using these other test sectors is to provide enough results to establish the presence or lack of certain horizontal and vertical trends in the results (see sections 6.4, 6.5). Also, it is of interest to test the effects of the specific purpose aggregations on sectors removed to varying degrees from the favoured sector.

In the model used, the test sectors for which multiplier and repercussion effects were calculated (where possible) are:

1. Forestry and logging (8) [1]
2. Sawmill products (36)
3. Rubber products (79)
4. Residential Building (86)
5. Other Building and Construction (87)
6. Motor vehicle repairs and service (90)
7. Transport and Storage (91)

6.3. METHODS OF AGGREGATION

As remarked in section 6.2 above, once the combination of sectors has been decided, the actual method by which the reduced model is produced must be selected. In this case, four alternatives have been examined.

6.3.1. The Output Weighting Method

As discussed in chapter 5 above, the most satisfactory theoretical approach when aggregating input output systems with a view to preserving multiplier and repercussion effects is to weight the sectors to be combined by their relative sizes, i.e. their total outputs. This is the approach normally used when input output systems are aggregated, and is here defined as the output weighting method.

6.3.2. The Equal Weighting Method

As the name implies, this method simply sums the relevant input coefficients of the sectors being aggregated, and then divides the sum by the number of original sectors in the new aggregated sector. This method provides a suitable control for testing the output weighting method. Moreover, it provides

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1 Sector number in the original model. Henceforth these sectors will be referred to by their numbers.

a fairly rigorous test of how closely the Hatanaka conditions have been followed in the various aggregations, since the ability of large sectors in a given combination to submerge the distorting effects of small, dissimilar sectors is greatly reduced. This method effectively averages the relative coefficients being aggregated.

6.3.3. The Flow/ALG Method

In the previous chapter, it was claimed that the Charnes--Cooper procedure could not be relied on to produce a satisfactory aggregated model. One basic problem with the method is that, while the set of minimized maxima of the column sum norms produced for a given system will be unique, the resulting matrix will not, and is heavily dependent on the initial feasible solution that was imputed because there is a "plateau of solutions " effect. A computer algorithm ALG was written to perform the Charnes-Cooper adjustment but required a feasible matrix as a starting solution. One such matrix is simply the flow matrix of the original system, and this approach is here defined as the Flow/ALG method.

6.3.4. The Coefficient/ALG Method

In Charnes and Cooper's exposition, the initial solution used was the coefficient matrix of the original input output system. This has been adopted here as an alternative initial solution to the flow matrix, and this approach defined as the Coefficient/ALG method.

Relating to 6.3.3 and 6.3.4 above, it is acknowledged here that there are any number of starting solutions which could be imputed into ALG, to produce a reduced model. No doubt some of these would produce better models in terms of preserving multiplier and repercussion effects, than the two used in this case. The only defence offered for the choice of these two alternatives is the lack of any formal procedure for choosing other, better initial solutions.

6.4. TESTING FOR REPERCUSSION EFFECTS PRESERVATION

The main problem was one of testing the nine aggregations in each of the four methods of producing a reduced model. The first test applied was the ability of the reduced models to preserve repercussion effects. As outlined in chapter 5, this in effect meant finding the nearest approximation of A* such that

$$\left[I^* - A^* \right] CX = CY$$

(terms as defined in Chapter 5)

The procedure used was to aggregate the 1967/68 model according to each of the nine combinations outlined in Appendix C and then to produce a Leontief inverse using each of the four methods outlined in section 6.3. The repercussion effects for the test sectors were then calculated by applying the appropriate matrix row to the reduced final demand vector. The resulting figure should have been the total output of that test sector - and it was compared to the equivalent figure in the disaggregated model to determine if any errors were present. Errors were calculated using the expression:

$$E_j = \left[\frac{X^*_j - X_i}{X_i} \right]^2 \qquad (1)$$

where

E_j = Output error index for test sector j in the aggregated model

X^*_j = Output for test sector j as calculated from the aggregated matrix

X_i = Output for test sector i (the corresponding sector for j in the aggregated model) in the disaggregated model

This error index gives an unbiassed estimate of the disparity and, because of the squaring of the expression, accentuates large individual errors. This is desirable, since large isolated errors must be regarded as seriously affecting the model's reliablity, even if the average error is low.

Table 6.1 gives the result of the error index calculation for the nine aggregations, tabulated in four groups of results corresponding to the four methods of forming the aggregated model. Errors were calculated for each of the test sectors except where the particular combination used absorbed that test sector into a composite sector (in which case the appropriate cell is marked with an asterisk). The sub-total row for each method gives the combined errors for each test sector, net of the "nonsense" aggregation - while the totals row figures include this error in each case where it applies.

The features of importance from these results are discussed below.

1. The output weighting method gave remarkably good results; even the 12 sector "nonsense" aggregation yielded E errors of less than .0001. The next best method is the equal weighting method, followed by the Flow/ALG method and lastly the coefficient/ALG method.

2. The "by eye" method of combining sectors gives consistently inferior results.[2] Admittedly, one of the "by eye" aggregations was also the smallest (33 sectors) (except for the "nonsense" aggregation), and therefore for that reason alone could be expected to have larger errors. However, the errors are substantially greater than the 37 sector $(I-A)^{-1}$ weighted aggregation. Moreover, the 50 sector "by eye" aggregation is consistently worse than the smaller aggregations wherein the combinations were done following the round-by-round or the $(I-A)^{-1}$ approach.

3. Exclusion of the "nonsense" matrix errors does not change the ranking of the four methods of aggregation, nor any of the internal rankings within each method's results.

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2 Note that only the sector No. 8 (forestry and logging) errors are compared when evaluating the methods of combining sectors, since this sector is the favoured one in each case.

TABLE 6.1

E. VALUES FOR AGGREGATIONS OF THE 1967/68 MODEL

METHOD	AGGREGATION (see APPENDIX C)	TEST SECTORS 8	36	79	86	87	90	91	ROW TOTALS
FLOW/ALG	65	.0167	.0153	.0201	.00	.0002	.0074	.0214	.1171
	33	.2510	.3331	.1368	*	*	.0619	.1325	1.1610
	50	.2510	.3083	.0561	*	*	.0322	.0744	.8748
	64	.0300	.0264	.0166	.00	.0007	.0088	.0181	.1298
	44	.1299	.0912	.0601	.00	.0042	.0457	.0654	.5094
	46	.0590	.0400	.0856	.00	.0036	.0419	.0669	.4047
	41	.0819	.0591	.1020	.00	.0080	.0528	.0771	.5047
	37	.1248	.1017	.1001	.00	.0079	.0475	.0698	.5914
	12	.6632	1.3481	*	*	*	*	*	
SUB-TOTALS		.9373	.9751	.5744	.00	.0246	.2982	.5256	
TOTALS		1.6005	2.3232						
OUTPUT WEIGHING	65	.00	.00	.00	.00	.00	.00	.00	
	33	.00	.00	.00	*	*	.00	.00	
	50	.00	.00	.00	*	*	.00	.00	
	64	.00	.00	.00	.00	.00	.00	.00	
	44	.00	.00	.00	.00	.00	.00	.00	
	46	.00	.00	.00	.00	.00	.00	.00	
	41	.00	.00	.00	.00	.00	.00	.00	
	37	.00	.00	.00	.00	.00	.00	.00	
	12	.00	.00	*	*	*	*	*	
SUB-TOTALS		.00	.00	.00	.00	.00	.00	.00	
TOTALS		.00	.00	.00	.00	.00	.00	.00	
COEFFICIENT/ ALG	65	.0044	.0060	.0029	.00	.00	.00	.00	.0436
	33	.1954	.3123	.0065	*	*	.0201	.0068	.7361
	50	.0508	.1251	.0211	*	*	.0007	.0014	.2095
	64	.0045	.0042	.0051	.00	.00	.0003	.0004	.0190
	44	.0682	.0069	.0092	.00	.00	.00	.0006	.1057
	46	.0319	.0388	.0119	.00	.00	.0017	.0042	.1112
	41	.0502	.0429	.0519	.00	.0007	.0059	.0073	.2427
	37	.0712	.0429	.0286	.00	.0013	.0001	.0048	.1408
	12	.8854	1.7972	*	*	*	*	*	
SUB TOTALS		.4766	.5416	.1972	.00	.0020	.0288	.0255	
TOTALS		1.3620	2.3388						

TABLE 6.1 Continued on next page

TABLE 6.1 (Continued)

65	.00	.00	.0003	.00	.00	.00	.0003	.0156
33	.0058	.0616	.00	*	*	.0012	.0036	.0749
50	.0068	.0631	.0056	*	*	.00	.0002	.0748
64	.0002	.0001	.0003	.00	.00	.00	.0003	.0010
44	.0063	.0021	.00	.00	.0001	.0009	.0010	.0188
ING 46	.0004	.00	.0019	.00	.0001	.0023	.0026	.0097
41	.0007	.0003	.0003	.00	.0020	.0014	.0013	.0062
37	.0049	.0023	.0002	.00	.0021	.0009	.0032	.0136
12	.0847	.1605	*	*	*	*	*	
SUB-TOTALS	.0251	.1295	.0086	.00	.0043	.0067	.0125	
TOTALS	.1098	.2900						

4. The individual column totals allow a rough ranking of each of the test sectors, in respect of the amount of distortion that arose in each one in the aggregation process. It is interesting to note that this ranking of sectors remained fairly consistent irrespective of which of the four methods of forming the aggregated matrix was used.

The most obvious conclusion to be drawn from these results is that the best procedure when aggregating for preservation of repercussion effects is to weight sectors to be combined by their relative output size. This is so irrespective of the degree to which models are aggregated. Further, it can be seen that, although the original 1967/68 model is large - and contains a very large number of interrelationships - quite small aggregations can be formed without producing appreciable errors.

The Charnes-Cooper procedure did not yield good results in any case where it was used. So far as repercussion effects are concerned, it can be concluded that the procedure, as employed here, is not a useful, practical method of aggregating input output models.

If, as was claimed in point 2 above, the use of the round-by-round or $(I-A)^{-1}$ systems for combining sectors is preferable to the "by eye" system then it may seem logical to reason that the test sectors which were not favoured by these combination systems should show higher errors than the one that was. There are, however, two factors which will have a bearing on this argument.

Firstly, not all the test sectors used have the same proportion of their output involved in the inter-industry section of the economy;

TABLE 6. 2

PROPORTION OF OUTPUT FROM TEST SECTORS THAT GOES TO INTERINDUSTRY DEMAND IN THE 1967/68 MODEL

Test Sector	8	35	79	86	87	90	91
Proportion of output delivered to interind. demand	74	1.00	.76	.00	.20	.49	.61

In general terms: if a given sector, i delivered all of its output direct to final demand, then row i in the $[I - A]^{-1}$ matrix will be entirely composed of zeros (except for the main diagonal element) Hence, in the case of industry i, the general relationship;

$$[I - A]^{-1} Y = X$$

in fact implies;

$$1.0 \times Y_i = X_i$$

and, since the Y vector is exogenous, this relationship is independent of aggregation in the interindustry matrix. Test sector 86 in Table 6.2 above is an example of this phenomenon and, as can be seen from the results in Table 6.1 this sector incurred no errors in any of the aggregation prodecures used. At the other extreme, test sector 36 supplies all of its output to intermediate demand - and its E errors are generally higher than those for the other sectors.

Secondly, there appears to be a rough correlation between sector size, and the amount of error produced in aggregation. This may be due to the particular aggregations used in this case or, more probably, it is due to the fact that more severe aggregation is required to produce a given percentage test error in a large sector than that required to give the same amount of error in a small one.

For these two reasons, it is deduced here that comparing unlike test sectors for aggregation error is probably unlikely to yield any useful information about the relative performance of the three systems of combining sectors.

6.5 TESTING FOR MULTIPLIER EFEECTS PRESERVATION

An analogous procedure to that outlined in Section 6.4 above was used to test for the preservation of multiplier effects in the nine aggregations and four methods. The multipliers used in this case are based on the method outlined in Chapter 4. For the 1967/68 model, multipliers based on wages, commodity tax, indirect tax and imports vectors were calculated. The procedure used to calculate error indices is similar to that given in section 6.4 above;

$$e_j = \left[\frac{M_j^* - M_i}{M_i} \right]^2 \qquad (2)$$

e_j = The multipliers index eroor for section j in the aggregated model.

M_j^* = The multiplier for test sector j as calculated from the aggregated matrix.

M_i = The multiplier for test sector i (the corresponding sector to j in the aggregated model) in the disaggregated model.

Rather than tabulate these errors individually for each multiplier, the errors for each of the four multipliers have been combined into a single figure (denoted hitherto as $\sum e$) for each case. The figure .0757 in the first cell in Table 6.3, for example, is the sum of the e values for the four multipliers for test sector 8 in that particular aggregation.

Table 6.3 is arranged on the same basis as Table 6.1 above. The results there indicate that;

1. The output weighting method again yields the best results, indicating that the theoretical superiority of this method (see Chapter 5) is borne out in practice for both the repercussion effects and multiplier cases.

TABLE 6.3

$\sum e$ VALUES FOR AGGREGATIONS OF THE 1967/68 MODEL

THOD	AGGREGATION (see APPENDIX C)	TEST SECTORS 8	36	79	86	87	90	91	ROW TOTALS
	65	.0757	.0580	.1157	.0796	.0568	.0363	.0635	.4556
	33	.7480	.6963	.6375	*	*	.3709	.2711	2.7238
	50	.5300	.5388	.1702	*	*	.1555	.1644	1.5589
	64	.1544	.1052.	.0473	.0316	.0336	.0460	.0588	.4769
OW/ALG	44	.3878	.3484	.2299	.1579	.1640	.2491	.1577	1.6948
	46	.3241	.2243	.4867	.1003	.1779	.2034	.1462	1.6629
	41	.4549	.2776	.3199	.0818	.1533	.2520	.1764	2.1709
	37	.4020	.3968	.5266	.1539	.1692	.2591	.2033	.
	12	.5877	2.3654	*	*	*	*	*	
SUB TOTALS		3.137	2.6418	2.5338	.9915	.7548	1.5723	1.2394	
TOTALS		4.723	5.0060						
	65	.0004	.0002	.0019	.0043	.0507	.0010	.0047	.0622
	33	.0090	.0091	.0518	*	*	.0368	.0117	.1094
	50	.0041	.0100	.0099	*	*	.0181	.0108	.0529
TPUT	64	.0013	.0031	.0025	.0149	.0158	.0012	.0054	.0442
IGHTING	44	.0634	.0036	.0056	.0065	.0133	.0221	.0115	.1260
	46	.0018	.0048	.0674	.0023	.0082	.0056	.0074	.0975
	41	.0053	.0007	.0075	.0160	.0641	.0101	.0060	.1097
	37	.0949	.0018	.0392	.0086	.0871	.0173	.0173	.2662
	12	.1943	.0911	*	*	*	*	*	.2854
SUB TOTALS		.1802	.0333	.1858	.0526	.2392	.1122	.0748	
TOTALS		.3745	.1244						
	65	.0343	.0321	.0149	.0571	.3843	.0028	.0055	.4710
	33	.8084	.6966	.5624	*	*	.0387	.0481	2.2042
	50	.2437	.2645	.1513	*	*	.0258	.0261	.7114
FFICIENT/	64	.0161	.0210	.0339	.0406	.0344	.0026	.0060	.1546
LG	44	.7216	.0185	.0782	.0792	.0776	.0149	.0124	1.0024
	46	.3746	.2709	.2717	.0634	.0564	.0249	.0509	1.1128
	41	.8562	.5292	.5663	.1460	.3761	.1425	.1242	2.7405
	37	.5452	.1991	.4920	.2299	.7327	.0333	.0403	1.2889
	12	18.6124	33.8408	*	*	*	*	*	52.4532
SUB TOTALS		3.6000	2.0319	2.5970	.6162	1.6615	.3355	.3135	
TOTALS		22.2120	35.891						

TABLE 6.3 continued on next pag

TABLE 6.3 (Continued)

	65	.0003	.0015	.0022	.0028	.0376	.0023	.0046	.0513
	33	.0362	.1327	.0638	*	*	.0534	.0125	.2986
	50	.0206	.1226	.0244	*	*	.0204	.0105	.1985
AL	64	.0012	.0005	.0077	.0112	.0133	.0018	.0015	.0372
HTING	44	.0728	.0104	.0035	.0041	.0110	.0254	.0111	.1383
	46	.0023	.0020	.0742	.0010	.0114	.0146	.0092	.1147
	41	.0033	.0022	.0114	.0075	.0459	.0181	.0067	.0951
	37	.0936	.0038	.0496	.0041	.0729	.0254	.0186	.4308
	12	.1745	.0850	*	*	*	*	*	.2595
SUB TOTALS		.2303	.2757	.2368	.0307	.1912	.1614	.0601	
TOTALS		.4047	.3607						

2. Based on this sample, there is no discernible ranking between the three systems of combining sectors, as there was in the case of aggregating to preserve repercussion effects.

3.Exclusion of the 'nonsense' matrix does not alter rankings.

4. The vertical and horizontal trends noted in points 4 and 5 of section 6.4 above are not as clearly defined in this case.

Apart from the general finding noted noted above that the output weighting method is again the best, two other general conclusions can be drawn from the figures in Table 6.3. Firstly, the Charnes - Cooper procedure has again failed to produce useful aggregations, and it would seem that, for all practical purposes, this procedure can be discarded. Secondly, the errors obtained in the multipliers were markedly higher than those arising from the repercussion error testing. Even allowing for the fact that the errors in this case are composites of four multipliers, the high order of the figures indicates that the preservation of multiplier effects is a much more sensitive factor than the preservation of repercussion effetcs when aggregating input output matrices.

6.6 THE 51 SECTOR MODEL

So far, three principles have emerged for the process of designing a functional special purpose aggregation of an input output system. These are ;

1. The sectors should be combined with reference to the $[I - A]^{-1}$ coefficients of the favoured sector.

2. The aggregation should be performed using the output weighting method.

3. Tests for reliability of the model should be geared towards investigating multiplier distortion[3] rather

[3]Provided, of course, that the resulting model is required for multiplier analysis or related work.

than the less sensitive repercussion effects distortion.

These principles were applied to the task of finding a suitable aggregation of the 1967/68 input output tables.

While the E and $\sum e$ indices employed above are useful for comparative purposes, they do not show directly how much distortion is present in the aggregations. For this purpose, it is more appropriate to use percentage distortions - which are in fact functionally related to the indices used. It will be accepted here that deviations of less than 5% from the disaggregated value are acceptable for multipliers of the favoured sector, and errors of less than 10% will be accepted elsewhere. The latter condition would not be necessary if only the favoured sector (forestry and logging) was of interest, and if its relationships with other industries were assumed not to change for the period of the analysis. However, in Chapter 8, it will be seen that some manipulation of the forestry and logging sector's relationships with other sectors is intended - and therefore some limitation of the amount of distortion present in those other sectors is required.

Trial and error testing of various aggregations formulated on the basis of the Hatanaka conditions and following the principles outlined above was carried out. Of those tried, the 51 sector aggregation given in Appendix C was the smallest which fulfilled the error requirements outlined above. Returning to the eight aggregations used for testing earlier in this chapter, it is clear from the results that the 51 sector aggregation performed better in this respect than any but the 64 sector aggregation, and only marginally worse than that one. Using the same test sectors as before, the percentage errors for the 51 sector model are given in Tables 6.4 and 6.5 below;

TABLE 6.4

PERCENTAGE DEVIATIONS OF REPERCUSSION EFFECTS PRODUCED IN THE 51 SECTOR AGGREGATION OF THE 1967/68 MODEL

Test Sector	8	36	79	86	89	90	91
Repercussion % Deviations	.007	.004	.006	.00	.00	.001	.001

TABLE 6.5

PERCENTAGE DEVIATIONS OF MULTIPLIER EFFECTS PRODUCED IN THE 51 SECTOR AGGREGATION OF THE 1967/68 MODEL

Test Sector	8	36	79	86	89	90	91
Wage Income Multiplier % Deviation	.04	.28	.55	.96	.48	.48	.35
Commodity Tax Multiplier % Deviation	.09	.67	7.44	.00	2.55	.03	.05
Indirect Tax Multiplier % Deviation	1.07	.39	3.14	2.47	3.63	3.00	3.08
Imports Multiplier % Deviation	3.07	1.48	5.80	3.16	1.43	1.07	6.93
Exports Multiplier % Deviation	1.85	3 78	.33	8.77	6 87	4.73	.66

If it is accepted that the test sectors used cover a sufficiently wide range of the interindustry matrix, then these percentage deviations indicate that the 51 sector aggregation is satisfactory in terms of the errors it produces. To allow comparison of the 51 sector model with those used in sections 6.3 and 6.4 above, the individual e indices for the 51 sector model are given in Table 6.6 below.

TABLE 6.6

e and Σe INDICES FOR THE 51 SECTOR AGGREGATION OF THE 1967/68 MODEL

Test Sector	8	36	79	86	89	90	91
Wage Income e Index	.00	.00	.00	.0001	.00	.00	.00
Commodity Tax e index	.00	.00	.0055	.00	.0006	.00	.00
Indirect tax e Index	.0001	.00	.0010	.0006	.0011	.0009	.0009
Imports e Index	.0009	.0002	.0034	.0010	.0002	.0002	.0048
Exports e Index	.0003	.0014	.00	.0076	.0047	.0022	.00

As noted above, the e indices and percentage deviations are functionally related.

In concluding this section, it is stressed that all that can be said for this 51 sector aggregation is that it is relatively free of major distortions in the repercussion or multiplier effects, and that it is small enough to considerably simplify the interindustry system. The fact that, so far as multiplier errors are concerned, the vertical and horizontal trends noted in sections 7.4 and 7.5 are not so apparent, implies the conclusion that individual sector results do, in the case of multipliers, vary more independently of each other than is the case in repercussion effects. This flexibility of results suggests that any real approach to an optimum aggregation within the defined error limits could only be made after the establishment of many more guidelines than were given in this chapter.

The 51 sector aggregation presented here is the one used for the regional analysis presented in chapter 8.

6.7. THE BUREAU OF CENSUS AND STATISTICS 30 SECTOR AGGREGATION

In the recently issued Australian Input Output Tables (CBCS (15)) a 30 sector aggregation of the 105 sector system is provided. It is of passing interest to examine the performance of this aggregation in terms of preservation of multiplier effects. If the combinations in that 30 sector aggregation are applied to the 1967/68 updating, and percentage errors calculated as outlined above, the following results occur.

TABLE 6.7

PERCENTAGE DEVIATIONS OF MULTIPLIER EFFECTS PRODUCED IN THE BUREAU OF CENSUS AND STATISTICS 30 SECTOR AGGREGATION OF THE 1967/68 MODEL

TEST SECTOR[4]	8	36	79	86
Wage Income Multiplier % Deviation	2.0	.36	6.3	2.4
Commodity Tax-Multiplier % Deviation	2.0	.6	4.1	1.1
Indirect Tax Multiplier % Deviation	.4	.6	3.7	1.4
Imports Multiplier % Deviation	5.2	7.9	47.3	10.3
Exports Multiplier % Deviation	3.0	2.5	8.8	.2.6

The repercussion errors, as would be expected from the results given throughout this chapter are low. However it can be seen from the results given in table 6.7 above, that the 30 sector Bureau model is not suitable for use in multiplier analysis.

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4 The four sectors are the only ones of the seven selected sectors that remain disaggregated in the 30 sector model.

CHAPTER 7
COEFFICIENT DRIFT

7.1 INTRODUCTION

There is a tendency in input-output literature to refer to the influences which disrupt the linearity of the input-output model as technology changes. The main conclusions would appear to be that only changes in technical knowhow produce changes in coefficients over time. In fact, a change in the pattern of inputs or outputs of a sector may be due simply to substitution brought about by normal mechanisms in the market place caused by differential price changes. The original classification of industries into input-output sectors is also a possible source of coefficient drift over time. In chapters 5 and 6, dealing with aggregation in input-output matrices, it will be seen that a fundamental theoretical requirement for non-distorting aggregation is that the industries combined have identical input structures. The fact that this requirement is almost never fulfilled in practice has important implications for aggregating input-output systems, but is also important to the stability of the model over time. If industries with dissimilar input structures are lumped into one sector and over time undergo differential growth rates (a not unlikely occurrence), then the coefficients pertaining to that industry must inevitably change. One test of the quality of an input-output model is how much this phenomenon occurs. This, in part, is why it is a somewhat dangerous practice to apply the empirical results of testing for coefficient drift on one model to another model, unless there is good evidence to suggest that the second model is not representing a situation where there has been a greater degree of technical innovation and price change, and does not contain a greater degree of aggregation of dissimilar sectors.

This necessary proviso may explain why there has been a range of opinion as to the significance of coefficient drift. Cameron (12) examined 52 industries for coefficient change over time, and found that:

a. 7 were not able to be fully observed.

b. 37 showed no marked change.

c. 8 did show a significant change, and this change tended to be linear.

Harmston and Lund (49) have provided evidence for a twenty year period by calculating the relationship between payroll and gross business wholesale trade in the United States. They found that the Payroll/Gross trade coefficient only varied between .1199 and .1352 for the whole period. Such a relationship as this is probably not as sensitive to changes in technology and prices, or to the other disruptive effects as are individual input coefficients, and would probably follow the more cyclic macroeconomic trends. Its application to estimating likely input coefficient movement over time is therefore probably fairly limited.

The U.N. publication on input-output analysis (89) does not provide empirical evidence relating to coefficient drift, but raises the point that the size distribution of coefficients in an input-output matrix is usually skewed; there are a few large coefficients and very many small ones. It is reasoned that the large coefficients will normally be more carefully observed, and because they are relatively more important this will tend to reduce estimation errors in the whole system substantially.

Evans (32) quotes evidence from Norway which suggests that over fifteen years of annual input-output tables, the coefficients have only varied about 2 % per annum.

Theil (86) compared input-output forecasting methods to more basic methods, and concluded from the results "... input-output method led to inferior results compared with the final demand blow-up extrapolation method when its tables are at least three years older than the extrapolation date." (p 18). Later in the same work it is claimed that, notwithstanding this finding, it is obvious that combining input-output data with more recent final demand data will always be better than extrapolation methods based on the same data. This claim will be of interest in sections 7.2 and 7.3 of this chapter.

Long (65) used regression techniques to decide whether or not linear homogeneity was preserved in the models he used. He concludes that this homogeneity was not realised in the majority of cases. McGilvray and Simpson (69) tested the 29 x 29 matrix of the Irish economy for 1956, for the behaviour of coefficients over time, and the affects on estimates of assuming that coefficients remain fixed over a short period of time. The important conclusions drawn from this work are that commodity/industry coefficients displayed a marked instability, that industry/industry coefficients are more stable and that there is a requirement for more detailed input-output matrices.(See the remarks in section 7.1 on aggregation effects, and the details in chapters 5 and 6.)

7.2 TESTING THE AUSTRALIAN MODEL

Some of the results referred to above were derived using different methodologies for assessing errors, and this to some extent explains the variation in the individual findings. Some of the differences noted, however, must be due to differences in model qualities (quality here being defined as the ability of a model to accurately represent the economy over a period of time).

It is necessary, therefore, to attempt to assess the ability of the Australian model to represent the actual situation over time, before using the model.

There is, of course, little point in testing for coefficient drift between the 1962/63 model, and the 1967/68 updating. Rather, it is more appropriate to assume that the RAS updating of the 1962/63 model to 1967/68 was successful (i.e. adequately cognizant of the actual changes that occurred in that period), and thence to test the 1967/68 model against an independently derived model for a reasonably well-separated year. In fact, the only other recent[1] output model of the Australian economy available is the 1958/59 model (CBCS (20)). A comparison between the 1958/59 model and the 1967/68 model is complicated by three factors:-

1. The number of sectors is different.
2. The actual definition of sectors is different in almost every case.
3. There is some variation in the treatment of factor inputs.

The task of comparison becomes one of combining certain sectors in the larger model so as to make the resulting sectors approximately comparable to sectors in the smaller model, and of making some of the factor inputs comparable. The latter is necessary in this case, because this study is concerned with modified multipliers, and it will therefore be of interest to examine the stability of these multipliers over time, as well as the stability of the coefficients. It cannot be assumed that because these multipliers are based in part on the coefficients, that they will therefore vary over time to the same degree.[2]

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[1] Cameron (11) constructed some small models for Australia in the early 1950's.

[2] In fact, the results given in tables 7.1 and 7.2 suggest that this may not be so.

In the two models tested, there were two factor input vectors which were common to both models; the "Wages, Salaries and Supplements" vector, and the "Imports" vector[3]. Hence two multipliers, the labour multiplier and the import multiplier, were obvious tests. A third multiplier, here referred to as the indirect taxes multiplier, could be used if the sum of "Customs Duty" vector plus the "Other Indirect Taxes (less subsidies) vector of the 58/59 model was regarded as being equivalent to the sum of the "Commodity Taxes (less subsidies)" vector plus the "Indirect Taxes N.E.C." vector plus the "Customs Duties" vector of the 67/68 model.

For testing coefficient stability, it was necessary to have at least some sectors common to both models. In this case, it was assumed that the dairying industry of the 58/59 model was equivalent to the "Milk,Cattle and Pigs" industry of the 67/68 model. The second common sector was approximated by combining the "Forestry and Logging" sector with the "Fishing and Hunting" sector of the 67/68 model - giving a sector much like the "Forestry and Fishing" sector of the 58/59 model.

"Wood Products" in the 58/59 model by deduction encompassed similar activities to those covered by the "Sawmilling" "Manufactured Boards" and "Wooden Furniture" industries of the 1967/68 model. These were therefore combined into one sector. Likewise, the "Building and Construction" industry in the 58/59 model was similar to a combination of the "Residential Building" industry plus "Other Building and Construction" industry of the 1967/68 model. Finally, the electricity industry was a substantial sized industry common to both models.

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3 It should be noted here that the 58/59 model used in this comparison was the one which had imports allocated directly. Producers prices were also used in both models.

It may be claimed at this point that the above procedure of combining sectors in the large model may produce the sort of aggregation distortions which have already been mentioned in section 7.1 of this chapter. This is posssible, but has been minimized in this case by using the appropriate aggregation procedure. It is claimed here on the basis of evidence presented in Chapter 6 that little distortion should result in using these procedures to aggregate a 105 sector matrix down to a 101 sector matrix, as has been done in this case.

From the two procedures, coefficients were produced. The relevant coefficients were extracted for comparison with the 58/59 data, and multipliers were calculated by inverting the Leontief matrix formed from the 101 sector aggregation.

Obviously, the only coefficients which can be compared are those which relate sectors common to both models. This restricted the assessment to the 40 coefficients relating input and output between the five test sectors used in this case. Some of these were zero, while others were so small that rounding differences between the two models affected them. In addition, there was some dup lication, since the input coefficient of one common sector from another common sector was also the output coefficient of the second sector. This was to some extent overcome by expressing output from one industry into another as both a fraction of the first's total output (in which case, for this purpose it was referred to as an output coefficient) and as a fraction of the second's total output (which was the normal input coefficient)

The figures in columns 3 and 4 were the mean/ base year coefficient discrepancy percentages. The figure expressed the difference between the average of the two coefficients, and whichever of them was selected as the base coefficient, as a percentage of that base coefficient.

i.e. if

a_{ij} = The input coefficient expression input from industry i into industry j in the base year

a' = The input coefficient expressing input from industry i into industry j in the other year.

then

$$D = \left| \left[a_{ij} - \left[(a_{ij} + a'_{ij}) / 2 \right] \right] / a_{ij} \right| \times 100$$

$$= \left| \left[a_{ij} - a'_{ij} \right] / 2 / a_{ij} \right| \times 100$$

and D is the mean/base year discrepancy percentage. This expression was not intended as an explicit statistical test. Rather, it was designed to indicate the order of variation present. Obviously, where this variation is high, there arises the factor of the D figure for a pair of coefficients based on one of them being quite different to the D figure based on the other. In Tables 7.1 and 7.2 below, the error terms calculated with figures from both models as the base have been given.

TABLE 7.1

SIGNIFICANT COEFFICIENTS IN THE RELATED TEST SECTORS OF THE TWO MODELS

Coefficients Type	Sectors	58/59 Value	67/68 Value	58/59 D.Figure	67/68 D.Figure
Input	Forestry/Wood Products	.232	.337	22.6	15.5
Input	Electricity/Wood "	.013	.012	3.8	5.6
Input	Building & Construction/ Wood Products	.003	.003	0.0	0.0
Input	Factory/Wood Products	.52	.092	38.5	21.7
Output	Wood Products/Electricity	.014	.001	46.4	650.0
Output	" " /Building & Construction	.537	.419	11.0	14.1
Input	Building Construction/ dairying	.019	.0003	49.2	3116.7
Input	Wood Products/Building & Construction	.110	.008	46.4	637.5
Input	Electricity/Dairying	.002	.0006	35.0	116.7
Output	Building & Construction/ Electricity	.0004	.0054	625.0	46.3
			TOTALS	877.9	4624.1
			AVERAGES	87.8%	462.6%

Table 7.2 below gives the D figures calculated in the same way for three multipliers for the test sectors.

TABLE 7.2

MODIFIED MULTIPLIERS FOR WAGE INCOME, INDIRECT TAXES AND IMPORTS FOR FOUR TEST SECTORS IN THE TWO MODELS

Sector	Multiplier	58/59 Value	67/68 Value	58/59 D.Figure	67/68 D.Figur
Forestry	Wage Income	.49	.610	12.24	9.4
	Indirect Taxes	.12	.092	333.0	43.48
	Imports	.19	.196	465.3	45.17
Wood Product	Wage Income	.63	.849	17.46	12.94
	Indirect Taxes	.066	.058	6.06	6.9
	Imports	.070	.312	172.86	38.78
Building & Construction	Wage Income	.67	.716	3.42	3.19
	Indirect Taxes	.076	.034	27.50	61.11
	Imports	.005	.234	51.83	25.45
Electricity	Wage Income	.51	.661	14.71	11.36
	Indirect Taxes	.42	.053	13.10	.0.38
	Imports	.045	.117	146.44	37.22
			TOTALS	934.2	306.0
			AVERAGES	77.85	25.50

It is difficult to know whether the samples used here (which were limited by the number of sectors available for testing) were sufficiently large and well selected to extrapolate the results to the general case. Assuming that the indications given were meaningful then the most interesting conclusion that can be drawn is that multipliers appeared to be more stable over time than individual coefficients. Also, the multipliers, seemed to exhibit a directional bias; tending to increase over time.

It may be argued with some justification that the variation in coefficients and multipliers noted here is not all due to the real-world, "legitimate" causes (technological changes, price variation and so on) but may also be partly attributable to artificial variables present in the analysis. For a start, the sectors compared are not exactly equivalent (see above) and some variation could result from this. Secondly, one of the models used has only 34 sectors, and as was seen in chapters 5 and 6 of this study, this degree of initial aggregation may not be reliable. Moreover, the 1958/59 model was constructed on the basis of fairly limited data (The Introduction to the newly released finalised version of the 1962/3 table admits as much of the 1958/59 model)

Whether or not this particular model <u>is</u> reliable is difficult to assess, because it depends very much on what criteria and methods were employed when industries were being aggregated into the 34 sectors.

Given these qualifications, it is still difficult not to regard the very large variation noted as an indication that a substantial amount of change occurred in the economy between the two years. The Australian models ability to account for the types of change that are apparently occurring must therefore be regarded as suspect, unless some adjustment for these changes is made. If the model to be used can be assumed to be relatively free of the aggregation types of distortion, then the adjustment for technological and price effects can be approximated using the RAS technique.

7.3 THE RAS TECHNIQUE

Suppose that since the construction of an input-output model, the economy that it represents has altered in such a way that the new final demand and factor input vectors are not a linear function of the originals. The

RAS technique, first proposed by Stone and Brown (84) in 1962, is an iterative procedure which allows adjustment of an interindustry model to conform with updated, exogenously derived vectors of final demand and factor inputs. A brief exposition of the method is given below;

Let

X = The vector of total sector outputs.

a_{ij} = The coefficient expressing input from industry i to industry j.

A = The matrix of coefficients.

B = The matrix of factor inputs.

Y = The vector of final demand

K = The vector of factor input totals for each sector.

E = The vector of total intermediate demand.

Q = The vector of total intermediate inputs

From the standard input-output relationship;

$$X = [I - A]^{-1} Y$$

by definition;

$$E = X - Y$$

$$E = [I - A]^{-1} Y - Y$$

$$= [[I - A]^{-1} - I] Y$$

Also:

$$K = BX$$

$$= B[I - A]^{-1} Y$$

Taking as known,

A_t = Matrix of input coefficients in year t.

X_{t+n} = The vector of total sector outputs in the later year t + n

Y_{t+n} = The vector of final demands in year t + n

Now, $E'_{t+n} = X_{t+n} - Y_{t+n}$

where, E'_{t+n} = The observed vector of intermediate demand in year t + n.

Using the coefficients of year n a, forecast of intermediate demand in the year t + n is given by;

$$E''_{t+n} = \left[\left[I - A\right]^{-1} - I\right] Y_{t+n}$$

In section 2, it was shown that in the Australian context, this estimate will probably be inaccurate, due to the amount of change of the coefficients between the years t and t + n. It is necessary, therefore, to introduce a system of weights, called r_j, such that if the diagonal matrix of r_j, called R, is applied to the matrix A_t then,

$$RA_t X_{t+n} = E'_{t+n}$$

This will alter the matrix to account for changes in the output patterns of the sectors over the time period. There will, of course, be an accompanying change in the input structures of the sectors over time;

If

K''_{t+n} = The forecast of the factor inputs totals vector, based on the original A_t matrix.

then

$$K'_{t+n} = SK''_{t+n}$$

where

K'_{t+n} = The observed factor inputs totals vector in year t + n.

S = The diagonal matrix of s_j weights.

This will adjust the matrix to account for changes in input structures.

Now, A_t can be replaced by A_{t+n}, where;

$$A_{t+n} = RA_t S$$

and now,

$$E_{t+n} - \left[\left[I - A_{t+n}\right]^{-1} - I\right] Y_{t+n}$$

where E_{t+n} is an improved estimate of the vector of intermediate demand.

The following example is included to demonstrate the facts that the method is convergent and iterative.

Consider the 2 sector economy represented by the input-output system below;

			E_t	Y_t	X_t
	10	12	22	20	42
	20	15	35	22	57
Q_t	30	27			
K_t	12	30			
X_t	42	57			

Assume that over the time period between years t to t + n, the exogenous vectors alter to

			E_{t+n}	Y_{t+n}	X_{t+n}
A_{t+n}	a	b	25	25	50
	c	d	41	20	61
Q_{t+n}	40	26			
K_{t+n}	10	35			
X_{t+n}	50	61			

Using the RAS technique, the elements of the rows of the matrix are multiplied in each case by an amount which alters the intermediate demand for that row to the observed value in year t + n.

		E_{t+n}
11.364	13.636	25
23.428	17.572	41
34.792	31.208	

The columns are then similarly adjusted to give the observed Q_{t+n} results.

	13.065	12.043	25.108
	26.935	15.517	42.452
Q_t	40	26	

The rows must now be re-adjusted to total the E_{t+n}

vector, and the procedure in continued until the interindustry matrix solves for the E_{t+n} values and the Q_{t+n} values:

13.4	11.6	25
26.6	14.4	41
40	26	

If, instead of making the first step in the iteration the alteration of the elements so that the rows total E_{t+n}, it is decided firstly to alter the elements so that the columns total B_{t+n}, the same solution will result. This is not to suggest, of course, that this solution is unique. The situation above is a set of simultaneous equations;

$$\begin{aligned} a &= 40 - c \\ c &= b + 15 \\ b &= 26 - d \\ d &= x \end{aligned}$$

If d is made equal to 16, then the matrix

$$\begin{bmatrix} 15 & 10 \\ 25 & 16 \end{bmatrix}$$

solves for the E_{t+n} and Q_{t+n} values. Since the RAS solution is not the only one available, there arises the possibility of deriving the solution via some mathematical programming technique, where constraints could be introduced according to what is required, rather than using the automatic procedural constraints imposed by the RAS technique. For instance, using the simple example above, suppose that there is exogenous evidence to suggest that only the minimal change necessary to produce the new situation occurred in all the coefficients. In this case, where a',b',c' d' are the new values, and

$$
\begin{aligned}
d - d' &= f_1(d) \\
b - b' &\quad f_2(d) \\
c - c' &\quad f_3(d) \\
a - a' &= f_4(d)
\end{aligned}
$$

then the problem becomes one of minimising the maximum of $f_i(d)$.

In matrix systems the number of constraints required increases in a geometric progression of the dimensions of the matrix, and this will mean that in large systems, many sets of constraints would be required. An interesting one which comes to mind is the exogenously derived multiplier. As noted in section 4.1 of chapter 4, Billings (3) has shown that the economic base income multiplier is identical to the standard input-output income multiplier, when the basic sector of the economic base model is made equivalent to the exogenous sectors of the input-output model. Economic base multipliers derived from the year t + n could therefore be instrumental in solving for A_{t+n}, if required.

In the situation at hand, it is neither necessary nor perhaps even possible to develop an adequate set of constraints, and therefore the RAS technique will need to suffice in providing an improved coefficient matrix. Paelinck and Waelbroeck (77) have provided empirical evidence that the technique yields good results. In a comparison between a 1959 RAS updating of 1953 Belgian input output data and the observed coefficients for 1959, it was found that for the 270 non-zero elements of the matrix;

1. 250 showed errors of less than 0.5%
2. 11 showed errors of 0.5 - 1.0%
3. 9 showed errors of greater than 1.0%

The writers emphasize that coefficients should be quantified through observation wherever possible. Their own work includes corrections of the RAS updated model used observed empirical data.

Bacharach and Bates (1) suggest that, in a study such as the one above, where knowledge is available of anomalous growth or diminution in a sector, or an irregular change in its input and/or output patterns, this should be imputed into the model as a condition on the RAS iteration. This in fact hints at the possible development of the technique along the lines of the mathematical programming approach mentioned above. In a less theoretical vein, chapter 8 of this study opens with an exposition of an approximation method for imputing new observed data into an existing input-output model, under certain restricted conditions.

For the purposes of this thesis, the 1967/68 RAS updating of the 1962/63 tables was regarded as a better approximation of the present day situation than the original model, and was used in preference to it.

CHAPTER 8

IMPUTATION OF REGIONAL INPUT OUTPUT DATA INTO THE NATIONAL MODEL

8.1 INTRODUCTION

In this chapter the 51 sector model developed in Chapter 6 will be used for the impuation of specific forestry input output data collected from two sample sources.

8.2 IMPUTATION OF REGIONAL DATA

The theoretical basis and development of regional input output models has received considerable attention in the literature and a large number of regional input output models have been constructed. When regional indirect effects need to be specified, there would seem to be little alternative to the costly research effort required to construct such models. However, when the national effects of a single regional industry, or a group of such industries are required, there is an alternative approximation method which utilizes the existing national model, thereby necessitating collection only of the specific industry input output data[1].

[1] Data could also be collected for the important supplying and processing industries until either the required level of accuracy was reached, or research funds were depleted.

The information yielded by this approach is useful to the national planner in two ways:

1. The national effects of a specific project could be assessed more accurately than would be the case if data derived from national averages were applied directly[2].
2. A given sector in the model could be disaggregated into the logical subsectors, by assessing inputs and outputs in a region representative of such a subsector and extrapolating the data so gained to the appropriate level.

Both of these uses will be demonstrated in the case studies presented in sections 8.3 and 8.4 below.

The method for imputation of regional data into a national model is quite simple. Consider the case of a national economy represented by the input output flow matrix F, comprising n sectors;

$$F = \begin{bmatrix} f_{11} \cdots\cdots f_{1j} \cdots\cdots f_{1n} \\ f_{j1} \cdots\cdots f_{jj} \cdots\cdots f_{jn} \\ f_{n1} \cdots\cdots f_{nj} \cdots\cdots f_{nn} \end{bmatrix}$$

let the vectors

$$X = \begin{bmatrix} x_1 \\ \vdots \\ x_j \\ \vdots \\ x_n \end{bmatrix} \qquad Y = \begin{bmatrix} y_1 \\ \vdots \\ y_j \\ \vdots \\ y_n \end{bmatrix}$$

be the total outputs and final demand vectors respectively and

$$A = \begin{bmatrix} a_{11} \dots\dots a_{1j} \dots\dots a_{1n} \\ a_{j1} \dots\dots a_{jj} \dots\dots a_{jn} \\ a_{n1} \dots\dots a_{nj} \dots\dots a_{nn} \end{bmatrix}$$

be the input coefficient matrix derived from F and X.

Following standard input output theory, the economy can now be represented in n equations by;

$$|I - A|^{-1} X = Y$$

Suppose now that inputs and outputs for the regional industry k, which is classified in the original n sector model under industry j, are independently assessed. An additional sector can now be appended to the model;

$$F' = \begin{bmatrix} f_{11} \dots\dots f_{1j} - f_{1k} \dots\dots\dots\dots f_{1n} & f_{1k} \\ f_{j1} \dots f_{jj} - f_{jk} - f_{kj} - f_{kk} \dots f_{jn} - f_{kn} & f_{jk} \\ f_{n1} \dots\dots f_{nj} - f_{nk} \dots\dots\dots\dots f_{nn} & f_{nk} \\ f_{k1} \dots\dots\dots\dots f_{kj} \dots\dots\dots\dots f_{kn} & f_{kk} \end{bmatrix}$$

such that for any row r;

$$\sum_{s=1}^{n+1} f'_{rs} = f'_{rj} + \sum_{\substack{s=1 \\ s \neq j}}^{n} f_{rs} + f_{rk}$$

where,

$$f'_{rj} = f_{rj} - f_{rk}$$

$$\therefore \sum_{s=1}^{n+1} f'_{rs} = f_{rj} - f_{rk} + \sum_{s=1}^{n+1} f_{rs} + f_{rk}$$

cancelling f_{rk} ;

$$\sum_{s=1}^{n+1} f'_{rs} = \sum_{s=1}^{n} f_{rs}$$

and for any column c;

$$\sum_{l=1}^{n+1} f'_{lc} = f'_{jc} + \sum_{\substack{l=1 \\ l \neq j}}^{n} f_{lc} + f_{kc}$$

where,

$$f'_{jc} = f_{jc} - f_{kc}$$

$$\sum_{l=1}^{n+1} f'_{lc} = \sum_{l=1}^{n} f_{lc}$$

The new total outputs vector of n + 1 elements will be given by;

$$X' = \begin{bmatrix} x_1 \\ \vdots \\ x'_j \\ \vdots \\ x_n \\ x_k \end{bmatrix}$$

where,

$$x'_j = x_j - x_k$$

and the new final demand vector of n + 1 elements will be given by;

$$Y' = \begin{bmatrix} y_1 \\ \vdots \\ y_j' \\ \vdots \\ y_n \\ y_k \end{bmatrix}$$

where,

$$y_j' = y_j - y_k$$

A new (n+1) x (n+1) element input coefficient matrix A' is formed, so that now the economy is represented in n+1 equations by;

$$\left[I' - A'\right]^{-1} Y' = X'$$

where I' is an identity matrix of dimension (n+1) x (n+1).

There is, as was remarked previously, no reason why only one additional sector can be appended to the model in this fashion. Any number of sectors, based on regional or industrial divisions, for which there are data available can be incorporated, with the appropriate adjustment to the 'parent' sectors being made accordingly.

This method is in fact a compromise between the highly data demanding construction of a regional model, and the use of the unadjusted national model for analysis of a regional industry or project. While it requires a return to the use of national average coefficients eventually, the method does allow the use of more specific data for the important first round, and possibly second and third round effects.

8.3 THE CENTRAL QUEENSLAND REGION DATA

At the time of writing, a rêsearch group in the Department of Economics at the University of Queensland was constructing a regional input-output model of the Central Queensland region.

For the purposes of this analysis, it is instructive to adopt the forestry input output data collected for that study for imputation into the 51 sector model using the procedure outlined in section 8.2 above.

The Central Queensland forestry data were taken primarily[3] from the proforma subtitled "Government Sector Primary Data Form" completed by the Queensland Department of Forestry for the regional input output study.

The model being completed by the University of Queensland group is differently defined to the 51 sector model in use in this thesis. For this reason, a number of adjustments were necessary to make the data compatible. These involved:-

1. The entries entitled "State Government Taxes" and "Commonwealth Government Taxes" and "Indirect Taxes" in the 51 sector model. Once the total was decided in this manner, the actual separation into commodity and indirect taxes was

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3. Much of the logging data was made available by Mr.J.Reilly of the A.N.U and formally of the Queensland Department of Forestry.

made in the same ratio as indicated by the forestry figures in the national model.

2. In the absence of adequate detailed trade data, it was assumed that the imports and exports[4] would be in the same proportion to industry output as in the national model. This assumption is acceptable here, because the direct import and export components of this industry are rarely significant compared to the indirect import and export effect.

3. Data on the distribution of outputs were not sufficiently detailed to allow direct allocation. The total inputs figure was assumed to be sufficiently accurate to use as the balancing figure, and total outputs were therefore assumed to equal the total inputs value.

4. Personal consumption was assumed to be in the same ratio to total output as in the national case.

5. A treasury loan figure of $178,000 was inferred, this being the amount required to balance outputs with inputs. This is not an unreasonable figure for forestry in this area.

Assumptions 4 and 5 above have relatively little significance in the multipliers derived in this case, and are therefore acceptable in this analysis.

Using these assumptions, the following table of the inputs and outputs of the forestry industry within the Central Queensland region was made;

[4]Note that these will be national imports and exports, not regional.

TABLE 8.1

SUMMARY OF INPUTS AND OUTPUTS IN THE FORESTRY INDUSTRY OF CENTRAL QUEENSLAND

Input	Value in $	Output	Value in $
Intermediate	363,120	Intermediate	859,100
Wages and Salaries	524,000	Personal Consumption	79,000
Taxes	22,000	Loan	178,440
Other Value Added	240,000	Exports less Imports	2,500
TOTAL	1,149,120	TOTAL	1,149,000

The intermediate output was predominantly deliveries to sawmills, and this simplified the analysis considerably.

The intermediate inputs, in terms of the 51 sector model, are listed for the Central Queensland region in Table 8.2 below. It should be noted here that the sector definitions in the Central Queensland model seemed to be based on the A.S.I.C. classification. Thus, some of the information developed in Chapter 4, combined with that given in the appendix to the preliminary Input Output tables (16) was able to be utilized here, in transferring sectors to the 51 sector classification. However, some areas of doubt still existed, and these are annotated and discussed below.

TABLE 8.2

INTERMEDIATE INPUTS FOR FORESTRY IN CENTRAL QUEENSLAND

Sector Number	Sector Name (Abbreviated)	Amount in $
6	Metallic Minerals, Non-Metallic Minerals etc.	100
26	Petroleum Products	59,100
27	Glass, Clay etc.	2,100
32	Cutlery, Handtools etc.[5]	6,400
37	Other Industrial Machinery and Equipment.[5]	83,000
39	Rubber Products[5]	5,000
41	Electricity, Gas, Water	1,300
43	Other Building and Construction	800
46	Motor Vehicle Repairs and Service[6]	68,000
47	Transport and Storage	116,123
48	Communications	7,989
49	Defence, Education, Welfare	5,000
50	Services, Landlords etc.	756
51	Business Expenses	8,402
	TOTAL	363,120

[5] These sectors contain all the input from the sector given in the Queensland model as 'Other Manufacturing', in the proportions 8:84:8 respectively. The proportions are based on the national average, weighted slightly for local effects.

[6] Includes all entries under 'Conveyances' in Queensland model.

The multipliers calculated from this sector are given in Table 8.5 below. General conclusions based on these and other figures are drawn there, but in the meantime some specific points related to the Central Queensland region can be made;

The high figure obtained for the wage income multiplier in the region is partly due to the high direct wage component. Nevertheless, if the direct wage component is netted out of both the regional and national average figures, the residual indirect effect is still higher in the regional case - indicating that this regional industry has a greater stimulative effect on the economy than the national industry as a whole.

It is interesting to note that, even though the direct commodity and indirect taxation components were assumed to be equal in the regional and national cases, the multiplier effects differ widely, with the revenues flowing to government by these means in the Central Queensland case being much lower than average.

Lastly, the import and export multipliers for this region imply that the industry here is less able to positively affect net foreign exchange reserves than is the national average case.

8.4 THE GREEN HILLS PLANTATION DATA.

The Green Hills plantation is an area of *Pinus radiata* located within the Batlow forestry sub-district in southern New South Wales. The forest is an exotic plantation under intensive management, and can therefore be expected to have a quite different pattern of inputs and outputs to the national average.

The data used in this study were compiled directly from the forestry office records, there being no previously collected regional input output data in existence for this region. Again, a series of assumptions had to be made before the data could be incorporated into the input output model. These are;

1. The difficulty of assessing gross operating surplus, and taxation figures for the regional industry necessitated the the calculation of total output (in input output terms) for the region by assuming that the sum of wages and intermediate inputs (both of which were able to be specified from the data) were in the same proportion as in the national model. This assumption is by no means infallible, but seemed to be the best that could be done short of a full scale regional assessment. When the total output is calculated in this fashion, the wages: total output ratio for the industry is slightly less than in the national case, and the intermediate inputs : total output ratio is slightly higher. This finding engenders some confidence in the assumption, in that it is the logical result for an industry which is more capital intensive than most other forms of forestry.

However, the figures can only be regarded as tentative, and should be used with care until more direct data on inputs and outputs are available.

The main groupings of inputs obtained from data collected were;

Wages input		$256,641
Intermediate input		$201,415
	TOTAL	$458,076

Using the assumption given, this total represents 55% of total inputs (according to the 1967/68 updated national model) - giving a total inputs figure of $832,864.

2. Commodity taxes, indirect taxes, inports and exports are all assumed to be in the same proportion to total inputs as their counterparts in the national model. These assumptions are similar to those used in the Central Queensland case, and appear to be reasonable on the grounds that the direct component of these factors do not play a significant role in the multipliers, or in the total output figure.

Based on these assumptions, a summary of inputs and outputs pertaining to the Green Hills forestry industry is as given in Table 8.3 below;

TABLE 8.3

SUMMARY OF INPUTS AND OUTPUTS IN THE FORESTRY INDUSTRY OF GREEN HILLS.

Input	Value in $	Output	Value in $
Intermediate	201,415	Intermediate	
		(Sawmills)	180,000
		(Pulpmills)	10,000
Wages and		Personal	
Salaries	256,641	Consumption	10,000

TABLE 8.3 (Cont'd)

Taxes	54,638	Loan	642,864
Other Value Added	320,150	Exports less Imports	
TOTAL	832,864	TOTAL	832,864

Intermediate inputs and outputs were derived from the detailed costing records held in the Batlow Sub-district Forestry Office. The Forestry Commission of New South Wales classifies operations under the following headings;

1. Reforestation
2. New Construction
3. Capital Improvements and Maintenance
4. Protection
5. Nurseries
6. Surveys
7. Research
8. Plant and Works Overheads
9. Marketing Supervision
10. Establishment Costs
11. Logging

Cost information for the various jobs performed under these headings is usually en tered as wages, materials, plant hire and, where applicable, contract. What actually comprises the materials used for the job in question can usually be derived from the files on completed jobs. Plant hire can be partitioned into the relevant input output sectors on the basis of machinery operation studies.Jobs performed under contract are more difficult to assess. In most cases, the best that could be done was to partition the contract amounts according to the breakdown for similar jobs performed by the Commission.

This procedure was used on all work carried out in the year, and the totals for each input sector calculated.

TABLE 8.4

INTERMEDIATE INPUTS FOR FORESTRY INDUSTRY AT GREEN HILLS

Sector Number	Sector Name (Abbreviated)	Amount in $
6	Metallic Minerals, Non-Metallic Minerals etc.	3,983
12	Prepared Fibres etc.	1,000
13	Carpets, Textiles etc.	127
24	Fertilizers, Chemicals etc.	3,745
26	Petroleum Products	26,607
27	Glass, Clay etc.	12,017
30	Non-Ferrous Smelting and Rolling	100
32	Cutlery, Handtools etc.	6,540
36	Electrical Cable etc.	840
39	Rubber Products	8,543
40	Plastics etc.	100
43	Other Building and Construction	7,000
46	Motor Vehicle Repairs and Service	45,097
47	Transport and Storage	30,736
48	Communications[7]	5,700
51	Business Expenses	3,500
	TOTAL	201,415

[7]This estimate is based on a proportional allocation of fees for communication equipment used in the Subdistrict, plus a depreciation factor of 10% on radio equipment.

The input output data generated was used to form a small sector in the 51 sector model, from which the relevant multipliers were calculated. Discussion of these multipliers is given in section 8.6 below.

8.5 THE RESIDUAL, OR PARENT SECTOR.

In the two-regional examples used above, the residual sector that would be left after deducting the new sector cash flows would be only 1% smaller than the original. A multiplier analysis of such a sector would not be particularly revealing, since the multipliers derived would be virtually identical to the original national multipliers. However, as noted in Section 8.2 above, the regional industry assessed can, if selected appropriately, can be used as an indicator for a particular type of sub-sector of the main industry. For example, the exotic plantation industry in Australia is quite different to the native hardwood industry.

If the Green Hills data noted above is accepted as being reasonably representative of the plantation forest industry in Australia, then by extrapolating the Green Hills flows to the point where they total the output of the exotic plantation industry in Australia (see Chapter 3), this sector can then be split off from the rest of the forestry sector. The resulting residual sector would be a composite of various forest types - eucalyptus, brushwood, Cypress Pine, Hoop Pine and so on. Since the great majority of this residual is native eucalypt forest, the residual sector can be regarded as reasonably representative of the eucalyptus hardwood industry.

Such a disaggregation of the forestry sector into these two groups is of more than academic interest. Plantation pine investment has greatly increased in Australia in the last decade or so. If this continues, planners will need to know how this type of forestry differs, both in its direct and indirect effect on the economy, from the other major type of forestry practice in Australia - the management of indigenous hardwoods.

From the figures given in Chapter 3, 26.8% of the total forestry output in the base year (1967/68) was from plantation pine. Based on this figure, and using the Batlow multipliers, the residual multipliers can be computed algebraically from the 1967/68 national multipliers. These multipliers, which will approximate those pertaining to the hardwood industry in 1967/68, are given below;

TABLE 8.5

FORESTRY MULTIPLIERS CALCULATED FROM REGIONAL AND NATIONAL DATA

Multipliers	National	Central Qld	Batlow	Residual (Hwd)
Wage Income	.663	1.102	.558	.669
Commodity Taxes	.046	.008	.040	.048
Indirect Taxes	.057	.026	.050	.050
Imports	.108	.203	.372	.104
Weighted Labour Coeff.		.310	.290	.270

8.6 SUMMARY

A general result arising from the foregoing figures is the wide disparity between the regional, national and residual multipliers. The main conclusion that can be drawn from these results is that direct application of aggregated figures (such as those in the national model) to regional areas can give erroneous conclusions.

Some of the more specific points arising from the results are;

In general, the highly stimulative effect of forestry noted in Chapter 4 is a consistent factor, regardless of the divisions of forestry examined. The extremely high wage imcome multiplier for the Central Queensland region is due to both the relatively high direct labour component, and to the slightly higher than average weighted labour coefficient. However, even when these two factors are netted out, the figure remains high - certainly higher than the equivalent agriculture figures given in Chapter 4.

The slightly lower than average wage income multiplier for the Batlow data is probably due to the particular industry examined being still in the developmental stage, with production falling well short of the eventual sustained yield capacity and processing requirement of the area. Presumably, the multiplier figure will rise as production and further processing increase - probably to a level equal to or greater than the national average.

No consistent result in the taxation multipliers was achieved. Probably the only conclusion that can be drawn from the taxation multipliers is that hardwood forestry generates a greater payment,per dollar of output, than the other types of forestry examined.

All types of forestry examined seem to have relatively little capacity to positively affect foreign exchange reserves, when compared to the agricultural industries. It is interesting to note that although the direct import and export figures for all the types examined were the same as the national average (because of the assumptions made), the multiplier figures vary quite widely between the subgroups of the industry.

It has been shown in this section that the effects of specific types of forestry on the national economy can be specified, using regional data. Apart from providing more directly applicable figures, the method has potential in identifying characteristics that are general to an industry (for example, the high wage income multipliers for forestry in this case) and in defining factors which vary widely within an industry.

Some of the general policy matters arising from these figures will be discussed further in the conclusions.

CHAPTER 9

SUMMARY AND CONCLUSIONS

9.1 ASSUMPTIONS

Input output analysis involves a series of assumptions necessitated by the linearity of the model. A review of the literature discussing the validity of these assumptions has been given at various stages throughout the thesis, and further critical attention has been directed to some of the more important points. Further testing of the Australian model was made possible, firstly by the derivation of suitable aggregation procedures outlined in Chapters 5 and 6, which allowed dissimilar models to be aggregated in such a way as to make certain derived sectors common to both. Secondly, the method given in Chapter 8 for imputation of regional data was shown to have application to testing the reliability of the model on a sectional basis.

The assumptions made in this thesis have already been discussed in detail. The more important of these are briefly outlined below:

1. It was assumed that the Monash team's RAS updating of the 1962/63 Australian model to 1967/68 was sufficiently accurate to allow the results to be extrapolated to present day conditions. While there is good overseas evidence to suggest that the RAS technique is successful, it must remain a matter of conjecture whether this applies to the model used in this study.

2. The 51 sector model was assumed, on the basis of random sector testing, to be a reasonably accurate condensation of the

105 sector 1967/68 updated model. Since the aggregation was done according to the theoretically most appropriate procedure and since accumulated multiplier errors in sectors quite removed from forestry in terms of inter-industry linkages did not exceed 10%, this assumption seems reasonable.

3. Numerous assumptions were made in Chapter 8 to allow the regional data collected to be imputed into the national 51 sector aggregated model. Following the observations made in the text none of these are very significant, in terms of the results quoted. However, they would need further examination if the conclusions drawn in Chapter 8 were to be extended or modified.

9.2 RESULTS AND CONCLUSIONS

A number of important general observations can be made from the results presented in this thesis. More specific conclusions are given either in the body of the thesis, or in Section 9.3 below.

As claimed in Chapter 1, the incorporation of indirect effects in land use evaluation is essential, if the decision maker is concerned with national rather than purely private costs and benefits. In Chapter 4, the input output model was used to develop several new multipliers for land use industries. The multipliers that resulted demonstrated the influences of these industries on the economy as a whole. The total wage income effects of the forestry sector differed widely from the meat cattle sector, for example, even though the direct labour inputs into the two industries, on a per dollar output basis, are fairly similar. Moreover, the particular groups within the work force are affected in quite different ways by the forestry sector. Similar differences in the effects of the land using industries examined on taxation generation and the foreign exchange factor were also noted.

Within the industries examined, there was also little correlation between the magnitudes of direct and indirect effects. Restricting the comparison even further the indirect effects of one sub-group of a given sector can differ materially from another, as can be seen from some of the regional results outlined in Chapter 8. This finding would undoubtedly also result in other sectors with discrete sub-groups. It is important to realise that these intrasectoral differences occurred in a model which has quite a large number of sectors, by input output standards, and also those sectors are well defined in terms of the Hatanaka conditions and other requirements. So the value of imputing regional or other specialized data into the input output model to improve model quality is obvious.

It is a basic claim of this work that the two major limitations of input output analysis (coefficient drift and aggregation distortion) should be examined for each model being used. It is clear from the range of results and opinions in the literature relating to coefficient drift that this factor is more related to the combination of sectors used and the stability of the economy being presented, than to more fundamental assumptions of the model.

It is apparent from the theoretical and empirical results reported in Chapters 5 and 6 that aggregation of the input output model can be carried out successfully provided sound procedures are used.

Considerable effort was given in this thesis to reviewing the theory of aggregation of Leontief systems, and to devising appropriate computer based techniques to empirically test the aggregation procedures. There are several reasons why this was necessary:

1. There was a lack in the literature of consideration of aggregating inter-industry systems with a view towards preserving multiplier effects, as well as the more common repercussion effects. As can be seen from the result given in Chapter 6, multiplier effects are in fact far more sensitive to aggregation distortion than are repercussion effects, and the research outlined in Chapters 5 and 6 is vindicated on this basis alone.

2. It was necessary to test the particular model in use for aggregation distortion since, as has been remarked previously, the results of empirical testing of one model in this area are not applicable to another model. The results obtained would indicate that the 51 sector model produced from the 105 sector Australian model is suitable for use in multiplier analysis related to the forestry sector, and in general seems to produce no drastic distortions in any part of the system.

3. There are important implications in the results not only for condensing the original model, but for the quality of the original model itself, since it also is an aggregation of the primary data. Some confidence in the 1962/63 and 1967/68 models is engendered when it is realised that these were originally formulated on the basis of the output - weighting method of combining sectors, and this method was shown in Chapters 5 and 6 to be the best available, in terms of preservation of both repercussion and multiplier effects.

9.3 POLICY INDICATIONS

Numerous data problems were encountered during the course of this thesis. Some of these, and the means by which they were resolved, were discussed in Chapter 4. More useful policy indications would have been possible had more regional forestry data been available. An attempt was made in early 1973 to obtain more regional forestry data of the type used in Chapter 8. Every state forestry organization in Australia was approached by means of a questionnaire which outlined the potential application and use of the study. A proforma based on the 51 sector model was included and the organizations were requested to fill this in on the basis of either whole state data, or data from a particular region. The response to this request was nil, so the regional studies were restricted to those where the writer was able to personally collect data - in one case from an existing regional input output study, in the other from primary sources.

Notwithstanding these problems, some of the specific results obtained have important implications for land use policy decisions. These are summarized below.

Most significantly, the highly stimulative capacity of the forestry industry, as reflected through the wage income multipliers, should be noted. This stimulative effect arose in the national case, and was present in both regional cases examined.

Equally consistent for the cases examined was the relatively low ability of the forestry industry to positively affect foreign exchange reserves. A quite radical shift in forest products prices would be required to lift forestry's balance of payment effect to the levels of the other land using industries.

Paradoxically, the foreign exchange argument has been frequently used as a defence for investment in forestry in Australia, while the economic stimulation factor has been virtually ignored.

Taxation generation - or at least that part of it indicated by the indirect and commodity tax multipliers - was higher for the forestry industry than for the other land use industries examined, although the Central Queensland results suggest that this may not be the case for all types of forestry operations. Considering the large taxation flow implicit in the high wage income multipliers, it appears obvious that the total taxation revenue stimulated by this industry will significantly exceed that of the other land use industries.

9.4 FURTHER RESEARCH

The utility of multipler analysis will depend on the length of the planning horizon, how quickly the structure of the economy is changing, and how well the planning model being used can be modified to predict future economic patterns. Obviously, a forest land use planner will of necessity have a long planning horizon - usually at least one rotation length (20-50 years). Consequently, information will be required on a range of local and overseas factors likely to produce basic economic changes. It has already been demonstrated in this thesis how input output models may be used to investigate the effects of industry changes, by imputing sub-sectoral data, and sector extrapolation.

However, to refine the results, further collection of regional data will be necessary. The information yielded by further work will be of great assistance to state forestry planning authorities, particularly for ranking the desirability of various alternative projects. At the national level, the collection and analysis of sub-sectoral data will also be highly applicable to the task of updating existing models, and understanding the structural dynamics of some sectors.

The specification of more exogenous vectors in the input output models will allow the computation of shadow prices, by means of calculation of multipliers related to subsidies, tariff effects, all forms of taxation and other factors which exercise effects over prices.

The Bureau of Census and Statistics, having standardized the structure and size of its input output model, intends to present up-dated models every five years. This will, to a certain extent, eliminate the need to test and modify older models before applying them to present day situations. However, until these models begin to appear, there is a need to constantly re-appraise the input output data wherever possible. Obviously, because of the importance of the tables as an analytical tool, the Bureau should endeavour to reduce the time involved between collection of the data, and publication of the tables.

9.5 PERSPECTIVE

It remains only to place the arguments presented here into the perspective of land use analysis in general.

The national land use planners seeking to maximize the net social benefit from land use, need information on:

(a) Potential production levels, actual performances and costs and prices relevant to the various land use alternatives.

(b) The appropriate criteria for assessing net social benefit, and what priorities and constraints exist.

(c) Whether the constraints finally decided on will be met, directly and indirectly, by the project being considered.

Points (a) and (b) above have been exhaustively examined in the large body of literature on forestry and agricultural economics. It is hoped that the methods and some of the results presented in this thesis have shown that requirement (c) is equally necessary, and should be incorporated as a matter of course into national project evaluations where either the government, the population at large, or both, have an interest in the outcome. Obviously, this will include practically all major projects to be evaluated.

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APPENDIX A

Updating the Labour Vector

1. Introduction

Since no wages and salaries vector was given in the 1967/68 updated input output model used in this study, it was decided to update the 1962/63 model's Wages and Salaries vector. Some features of this updating require discussion.

2. Primary Industries

Since the owner-operator adjustment was only performed on the three agricultural industries mentioned in Chapter 3, only these industries of the eight agricultural industries are updated here. The fact that the other five industries were not altered from their 1962-63 levels will not be of any importance here, since none of these industries is involved to any significant degree (directly and/or indirectly) with industries for which multipliers are calculated in this work.

In the absence of data on wage payments that are compatible with the input-output classification, the labour coefficient for forestry and the three agricultural industries must be updated by less direct means. Consider firstly the case of forestry.

The first assumption that must be made is that the proportion of average wage rates in forestry : average minimum weekly wage rates for Australia was constant over the period 1962/63 - 1967/68. Now if

l_f = Labour coefficient for forestry in base year.
W_a = Av. min. weekly wage rate in base year.
X_f = Output of forestry sector in base year (in \$)
N_f = No. of workers employed in forestry in base year.
W_a' = Av. min. weekly wage rate in updated year.
X_f' = Output of forestry sector in updated year (in \$).
N_f' = No. of workers employed in forestry in updated year.

then,

$$l_f' = l_f \times \left[(N_f'.W_a'/X_f') \; / \; (N_f.W_a/X_f) \right]$$

where,

l_f' = Labour coefficient for forestry in updated year.

In 1963, the average minimum weekly wage rate was $37.55, and in 1968 it was $48.98*.

The number of workers employed in forestry in 1963 was 9,364 and by 1968 this had fallen to 8,933.** From the 1962/63 input-output table, the forestry and logging sector's output was $123.2 m, while the updated (1967/68) table gives an output figure of $148.4m for this industry. Hence, if the assumptions implicit in this method are accepted, the labour coefficient for 1967/68 should be;

$$.31 \times \frac{\dfrac{48.98 \times 8933}{148.4}}{\dfrac{37.55 \times 9364}{123.2}}$$

$$= .32 \text{ approx.}$$

This indicates that the labour coefficient for forestry rose by approximately 3% over the period.

In the case of the agricultural industries, it is difficult to separate the numbers employed into the input-output classes, so in this case a composite figure including all the agriculture industries must be used. From the Rural Industries Bulletin No. 5, the numbers employed in agriculture in the base year was 465,238, and in the update year, the figure was 457,507. Using composite output figures calculated from the input-output tables of $2628m and $2796m for the base and update years respectively;

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* From the Labour Report No. 54 Bureau of Census and Statistics, Canberra.

** From the Non-Rural Primary Industries Bulletin (22)

$$l_a' = l_a \times \frac{\frac{48.98 \times 457{,}507}{2796}}{\frac{37.55 \times 465238}{2628}}$$

where,

l_a = Base year labour coefficient for agriculture

l_a' = Update year labour coefficient for agriculture

Based on this figure, the average agriculture labour coefficient rose by approximately 20% over the period. In the absence of more specific data (due to the classification problem mentioned above), this figure has been applied as a correction factor to the three agriculture industries. Obviously this method is not wholly satisfactory, but should at least improve the estimate of labour requirements in these industries in the update year. It should be mentioned at this point that the adjustment procedure given above was applied only to the labour figure given in the 1962/63 input-output table. The owner operator labour has been calculated on the basis of more recent data, and therefore does not require this adjustment.

3. Mining Industries

The three mining industries were updated (for wages and salaries) by using the 1968 figures given in CBCS(22)

4. Manufacturing Industries

The manufacturing industries have, where possible, been updated using economic census figures from the Bureau of Census and Statistics publication; 'Manufacturing Establishments and Electricity and Gas Establishments', and the 1968-69 figures given in that publication were used in this case. Because the A.S.I.C. (CBCS(17)) classification used in the above publication was not completely compatible with the Input-Output Table classification, some problems arose. As will be seen from the Appendix accompanying the 1962-63 Input-Output Tables, many input-output sectors contain 'parts' of A.S.I.C. industries - but no figures are given as to what proportion of the A.S.I.C.

industry this 'part' represents in each case. A value judgment must be made in each case where this problem arises as to whether the part of the A.S.I.C. industry is going to be a significant proportion of the industry or not. If it is, then all that industry's labour is included in the input-output sector. If it is decided that only a small proportion of the A.S.I.C. industry's total output forms the 'part' in question, then the labour from that industry is completely excluded from the input-output sector in question.

This procedure is more accurate than may first appear because, in this case, most of the A.S.I.C. industries which were classified in this manner were either fairly small industries, or were very obviously either largely 'in' or 'out' of the input-output sector in question. Where a value judgment was difficult to make, the process was not used. In such cases, the 1962-63 labour coefficients were used directly to estimate labour inputs. Also, in the five land use industries which were not updated, and in the industries for which more recent data was not available (Nos. 85 to 105 in the input-output table), the old labour coefficients were used to estimate labour inputs. In all cases where the old coefficients were used, the figure is marked in the table with an asterisk.

The fact that some of the new labour coefficients differed quite markedly from the equivalent old ones in this updating procedure indicates that an updating was necessary. The one given here is not wholly satisfactory, since only 59 of the 105 figures were actually updated, and in these 59 figures there will occasionally be slight underestimates and overestimates occurring because of the definition discrepancy problem discussed above. This group of 59 does, on the other hand, include the great majority of sectors that have significant dealings with the four land use industries for which income multipliers were calculated. It can be reasonably asserted that the wages and salaries vector computed from the updated labour coefficient vector given here will be markedly closer to the real situation that existed in 1967/68 (the base year of the updated input-output model) than the one derived from the 1962/63 labour coefficient vector.

TABLE A1

UPDATED LABOUR COEFFICIENTS+

1	.3500	30	.4194	59	.1989*	88	.4067
2	.1300	31	.1926	60	.3308	89	.4572*
3	.0228*	32	.1301*	61	.2029*	90	.3828*
4	.3300	33	.227	62	.2589*	91	.3287
5	.0554*	34	.3340	63	.2842*	92	.4948*
6	.0504*	35	.2898	64	.2885	93	.6979*
7	.1316*	36	.2819*	65	.2459	94	.4324*
8	.3200	37	.2829	66	.2624*	95	.2219*
9	.2161*	38	.3722	67	.2491	96	.6710*
10	.2214	39	.1346*	68	.5217	97	.4506*
11	.3263	40	.1858	69	.4367	98	.5120*
12	.2889	41	.2436*	70	.4068	99	.7333*
13	.0222*	42	.4118	71	.3009	100	.8083*
14	.1252	43	.3745	72	.3373	101	.3465*
15	.1306	44	.1532*	73	.2694	102	.3885*
16	.1806	45	.3319*	74	.2946	103	.5342*
17	.0988	46	.1832*	75	.2187	104	.00
18	.0754	47	.2078	76	.2163*	105	.00
19	.2822	48	.1806	77	.2375*		
20	.1083*	49	.1871	78	.2909		
21	.2178	50	.2115*	79	.3409*		
22	.1680*	51	.0405	80	.3734		
23	.2345	52	.3952	81	.1841*		
24	.1563	53	.3888	82	.2483		
25	.1629	54	.2223	83	.3434		
26	.1088	55	.3012	84	.3389		
27	.0760	56	.2079	85	.3008*		
28	.1811*	57	.4339*	86	.2574*		
29	.1757	58	.0870	87	.3228*		

+ Including owner operator adjustment in the Sheep, Wheat and Meat Cattle industries.

TABLE A2

UPDATED LABOUR INPUTS

1	297.0	32	8.4	63	72.0	94	135.7
2	43.4	33	46.2	64	7.3	95	69.6
3	1.5	34	163.9	65	30.3	96	624.7
4	120.1	35	44.4	66	44.0	97	467.9
5	28.2	36	98.0	67	269.2	98	417.8
6	7.8	37	71.2	68	75.7	99	636.5
7	68.3	38	63.2	69	83.9	100	76.0
8	44.9	39	26.0	70	50.0	101	178.1
9	7.9	40	39.7	71	32.5	102	402.1
10	90.6	41	28.3	72	89.4	103	186.3
11	79.6	42	108.6	73	88.0	104	0.0
12	36.1	43	126.4	74	132.1	105	0.0
13	0.7	44	66.0	75	44.5		
14	139.3	45	19.4	76	151.8		
15	69.1	46	7.6	77	9.5		
16	42.2	47	24.8	78	10.3		
17	9.3	48	39.1	79	84.7		
18	27.4	49	19.2	80	80.1		
19	89.7	50	9.8	81	4.8		
20	36.0	51	26.3	82	3.8		
21	22.7	52	32.7	83	238.0		
22	20.3	53	54.9	84	36.6		
23	24.7	54	67.6	85	66.2		
24	29.9	55	22.2	86	306.0		
25	8.8	56	209.2	87	981.6		
26	17.4	57	138.7	88	644.6		
27	12.0	58	47.2	89	1036.1		
28	40.6	59	77.0	90	199.7		
29	35.2	60	96.6	91	854.6		
30	11.2	61	27.2	92	331.5		
31	14.6	62	15.0	93	392.2		

TABLE A3

LABOUR COEFFICIENTS - 1962/63 MODEL

1	.1536	33	.2736	65	.2284	97	.4506
2	.0292	34	.2949	66	.2624	98	.5120
3	.0228	35	.3528	67	.2033	99	.7333
4	.1104	36	.2819	68	.3953	100	.8083
5	.0554	37	.3234	69	.5297	101	.3465
6	.0504	38	.2899	70	.3405	102	.3885
7	.1316	39	.1346	71	.1920	103	.5342
8	.3027	40	.1899	72	.3041	104	.00
9	.1261	41	.2436	73	.2548	105	.00
10	.3927	42	.3003	74	.2434		
11	.1517	43	.414	75	.2311		
12	.1435	44	.1532	76	.2163		
13	.0222	45	.1912	77	.2375		
14	.1015	46	.3319	78	.2582		
15	.0992	47	.1832	79	.3409		
16	.1828	48	.1869	80	.2523		
17	.1140	49	.1715	81	.1841		
18	.1039	50	.2115	82	.1758		
19	.2203	51	.0529	83	.2658		
20	.1083	52	.2289	84	.2794		
21	.2168	53	.3487	85	.3008		
22	.1680	54	.2333	86	.2574		
23	.2081	55	.3100	87	.3228		
24	.1704	56	.2588	88	.4067		
25	.1100	57	.4339	89	.4572		
26	.0899	58	.0923	90	.3828		
27	.0953	59	.1989	91	.3287		
28	.1811	60	.2949	92	.4948		
29	.1219	61	.2029	93	.6979		
30	.3641	62	.2589	94	.4324		
31	.2020	63	.2842	95	.2219		
32	.1301	64	.1552	96	.6710		

APPENDIX B

Skill Group Classification

Below is a brief summary of the skill group classification referred to in Chapter 4.

1. Professional, technical and related workers. Includes government administration and executive officials, some employers and workers on own account, pilots, flight engineers etc.
2. Clerical and related workers. Includes draughtsmen and designers, precision instrument makers etc., artists etc.
3. Sales workers. Includes transport and communications workers most production process workers, farm, mining, and forestry workers.
4. Unskilled workers.
5. Unclassified.

APPENDIX C

Aggregations of the 1967/68 RAS Update of the 1962/63 Input Output Table.

The following tables give the aggregations of the 1967/68 input output models used in this thesis. Tables C1, C2 and C3 give the aggregations used for empirical testing in Chapter 6, under the headings discussed in that Chapter*.

Table C4 gives the 51 sector aggregation used for imputation of regional data in Chapter 8.

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* For convenience, the 12 sector 'nonsense' aggregation has been included in the 'round-by-round' table, although of course no particular method was used for the nonsense combination.

TABLE C1

$\left[I - A\right]^{-1}$ BASED AGGREGATIONS OF THE 67/68 MODEL

64 Sector Model				37 Sector Model				41 Sector Model			
New Sector No.	Original Sector No.	NS	OS	NS	OS	NS	OS	NS	OS	NS	OS
1	1	33	53	1	1,4-6,9	33	91	1	1-7,9	33	86
2	2,3,7	34	56	2	2,3,7	34	89,92-95	2	8	34	87
3	4	75	57	3	8	35	96-100	3	10,12-13	35	88
4	5,9	36	58,59	4	10-13	36	101-104	4	11	36	90
5	8	37	60	5	14-16	37	105	5	14-26	37	91
6	10,12,13	38	61,62	6	17-26			6	27-35	38	89,92-95
7	11	39	63	7	27-35			7	36	39	96-100
8	14	40	64-66	8	36			8	37	40	101-104
9	15	41	67	9	37,38			9	38	41	105
10	16-20	42	68-70,75	10	39,40			10	39		
11	21-24	43	71-73	11	41			11	40		
12	25,26	44	74	12	42,43			12	41		
13	27,28	45	76	13	44-48			13	42		
14	29	46	77,78	14	49,50			14	43		
15	30-33	47	79	15	51			15	44		
16	34	48	80-82	16	52,54,55			16	45-48		
17	35	49	83	17	53			17	49		
18	36	50	84,85	18	56			18	50		
19	37	51	86	19	57			19	51		
20	38	52	87	20	58-60			20	52,54-55		
21	39	53	88	21	61-66			21	53		
22	40	54	90	22	67			22	56		
23	41	55	91	23	68-70,75			23	57		
24	42	56	89	24	71-74			24	58-66		
25	43	57	92-95	25	76			25	67		
26	44	58	96	26	77,78,80-82			26	68-70,75		
27	45,46	59	97	27	79			27	71-73		
28	47	60	98	28	83-85			28	74		
29	48,49	61	99,100	29	86			29	76		
30	50	62	101-103	30	87			30	77,78, 80-82		
31	51	63	104	31	88			31	79		
[illegible]	[illegible]	[illegible]	[illegible]								

TABLE C2

'BY EYE' AGGREGATIONS OF THE 67/68 MODEL

33 Sector Model				65 Sector Model				50 Sector Model			
New Sector No.	Original Sector No.	NS	OS	NS	OS	NS	OS	NS	OS	NS	OS
1	1-7,9			1	1	34	48	1	1	34	74,75
2	8			2	2,3	35	49,50	2	2,3,7	35	70
3	10-13			3	7	36	51	3	4,6	36	77,78
4	14-22			4	4,6	37	52-55	4	5,9	37	79
5	23-26			5	5,9	38	56	5	8	38	80-82
6	27-35			6	8	39	57	6	10-13	39	83
7	36			7	10	40	58-60	7	14	40	84,85
8	37			8	11	41	61-63	8	15	41	86,87
9	38			9	12,13	42	64-66	9	16-20	42	88,89
10	39			10	14	43	67	10	21-24	43	90
11	40			11	15	44	68-70,75	11	25,26	44	91
12	41			12	16	45	71-73	12	27-29	45	92-95
13	42			13	17-19	46	74	13	30-33	46	96-98
14	43			14	20	47	76	14	34,35	47	99,100
15	44-50			15	21-24	48	97,78	15	36	48	101-103
16	51			16	25	49	79	16	37,38	49	104
17	52-55			17	26	50	80-82	17	39	50	105
18	56-63			18	27,28	51	83	18	40		
19	64-66			19	29	52	84,85	19	41		
20	67			20	30-33	53	86	20	42,43		
21	68-70			21	34	54	87	21	44		
22	71-74			22	35	55	88	22	45,46		
23	75,76			23	36	56	89	23	47		
24	77,78, 80-82			24	37	57	90	24	48-50		
25	79			25	38	58	91	25	51		
26	83-85			26	39	59	92	26	52-55		
27	86-87			27	40	60	93-95	27	56		
28	88-89			28	41	61	96,97	28	57-60		
29	90			29	42	62	98-100	29	61-63		
30	91			30	43	63	101-103	30	64-66		
31	92-95			31	44,45	64	104	31	67		
32	96-104			32	46	65	105	32	68-70		
33	105			33	47			33	[illegible]		

TABLE C3

'ROUND BY ROUND' AGGREGATIONS OF THE 67/68 MODEL

44 Sector Model				46 Sector Model				12 Sector 'Nonsense' Model			
New Sector No.	Original Sector No.	NS	OS	NS	OS	NS	OS	NS	OS	NS	OS
1	1,4-6,9	33	77,78, 80-82	1	1,4-6,9	33	77,78, 80-82	1	1-7,9		
2	2,3,7	34	79	2	2,3	34	79	2	8		
3	8	35	83-85	3	7	35	83	3	10-35		
4	10-13	36	86	4	8	36	84,85	4	36		
5	14	37	87	5	10	37	86	5	37-50		
6	15	38	88,89, 101-103	6	11	38	87	6	51		
7	16-22	39	90	7	12,13	39	88	7	52-66		
8	23-26	40	91	8	14-26	40	90	8	67		
9	27,28	41	92-95	9	27-35	41	91	9	68-80		
10	29-32	42	96-100	10	36	42	89,92-95	10	81-90		
11	33	43	104	11	37	43	96-100	11	91-100		
12	34	44	105	12	38	44	101-103	12	101-105		
13	35			13	39	45	104				
14	36			14	40	46	105				
15	37-38			15	41						
16	39-41			16	42						
17	42,43			17	43						
18	44			18	44-50						
19	45-50			19	51						
20	51			20	53						
21	52-55			21	54						
22	56			22	52,55						
23	57			23	56-59						
24	58,59			24	60						
25	60-64			25	61-66						
26	65,66			26	64						
27	67			27	67						
28	68-70			28	68,70						
29	71-73			29	69						
30	74			30	71-74						
31	75			31	75						
32	76			32	76						

TABLE C4

51 SECTOR AGGREGATION OF THE 67/68 MODEL

New Sector No.	Original Sector No.	NS	OS
1	1	27	52-55
2	2,3,7	28	56
3	4	29	57
4	5,6,9	30	58,59,60
5	8	31	61,62,63
6	10,12,13	32	64,65,66
7	11	33	67
8	14	34	68-70,75
9	15	35	71,72,73
10	16-24	36	74
11	25,26	37	76
12	27,28	38	77,78
13	29-33	39	79
14	34	40	80,81,82
15	35	41	83,84,85
16	36	42	86
17	37	43	87
18	38	44	88
19	39	45	89
20	40	46	90
21	41	47	91
22	42	48	92-95
23	43	49	96-100
24	44,45,46	50	101-104
25	47-50	51	105
26	51		

APPENDIX D

Driving Instructions for Program AG and Associated Data Files

1. Introduction

The program is designed to perform three basic tasks;

1. Read in the input-output data (1967/68 version) from a data file.

2. Aggregate the input output system down to a smaller size, which is determined by consolidation data read in from a file or cards.

3. Calculate and print out multipliers, matrix tests and errors for nominated industries.

Various options are available within this framework.

2. Data

(a) Interindustry data and the relevant vectors were read from cards with the use of program AGGDAT, and stored in matrix conformation on UNIT 8 of the ANU machine, under the file name AGGDAT.

(b) There exists an option in the main program to write out the multiplier results to a file, so that these can be read in a later run for error calculation. UNIT 9 is used for this purpose in the program.

(c) Subroutine CONS of the program requires aggregating data in the form of a rectangular matrix of zeroes and ones. The combination of ones on any one line of this data will determine which sectors are combined in the aggregate model. Because of the 80 column limitation, every line of the aggregated model will require two cards, to cover the 105 sector dimension of the original matrix in AGGDAT. Thus, if it is required to aggregate sectors 1, 2 and 3 of the original model, then a card with ones punched in the first three columns is entered, followed by a blank card (the program interprets blanks as zeroes in this case). Alternatively, if sectors 93 and 94 are to be combined, a blank card is entered first, then a card with ones punched in the 13th and 14th columns. Note that all 105 sectors must be represented by a one somewhere in the aggregating matrix, otherwise floating point errors will arise.

Two such aggregating matrixes exist on the ANU tape. File KAL is a 105 sector matrix - i.e. it does not aggregate the AGGDAT data at all, and is used when disaggregated figures are required. The KAT is a 51 sector aggregating matrix, which produces little distortion (See Douglas, Ch. 7) in the test sectors. Any other combination of sectors would need to be entered as card data when the program is run.

Files KAL and KAT also contain two lines of sectoral and options information, which precede the aggregating matrix, and would similarly be required in front of an aggregation matrix data deck entered by the user.

Card 1; 10I5 Format.

Up to 10 numbers are entered. The first number determines the number of sectors for which multipliers are to be calculated (variable name NE). The subsequent string of numbers will be the actual sector numbers for which multipliers are to be calculated. Note that these numbers refer to sector numbers in the aggregated system (if an aggregation has been carried out). (Vector name ISUBS.)

Card 2; 8I10 Format.

Eight numbers are entered. The first number is the number of sectors in the disaggregated model (105 when AGGDAT is the data source) (Variable name NO). The second number is the number of sectors in the aggregation (e.g. 30 if the 105 sector model is to be consolidated into a 30 sector model). (Variable name M). The third number refers to the maximum number of sectors allowed in the aggregation - and will always equal NO. (Variable name MSR). The remainder of the numbers are options to allow direction of the program;

4th No:

1	if it is desired to aggregate the flow matrix	variable name; ICOEF
0*	if it is desired to aggregate the coefficient matrix.	

5th No:

1	if normal aggregating process is required	variable name IALG
0**	if specialised aggregating algorithm is required	

---

* This option will not be selected for normal use (See Ch. 5)

** This algorithm is inapplicable to use for multiplier work, and should not be used to this end. (Ch. 5)

6th No;

0	if new input output data to form a new sector in the model is to be entered	)	variable name IMPUT
1	if no new data is to be entered	)	

7th No;

1	if multiplier results are to be written out to a nominated file in unit 9	)	variable name NUM
0	if multiplier results stored in a file in Unit 9 are to be read in and used for error calculation	)	

8th No;

1	if it is desired to initialize an extra sector to zero in preparation for data imputation. This option will always be used if IMPUT above is set to 0	)	variable name NEWM
0	if no initializing is required	)	

As remarked above, if files KAL or KAT are being used, these two data lines are already included, although they may require editing to suit the users purpose.

(d) If the option to impute a new sector is selected (IMPUT = 0),

Card 1; (Format (I3, 6(I3,F8.3))*

1st No;

An integer greater than -1

2nd No;

An integer corresponding to the number of the new sector (usually M + 1).

---

* With the current program design, only the first of the six bracketed format fields is used.

3rd No;

A real number giving the labour input to the new sector.

Card 2;

1st No;

An integer greater than -1

2nd No;

An integer as for card 1 above.

3rd No.

A real number giving the total output of the new sector.

Cards 3 - 7;

Repeat this process for the new sector amounts for final demand, commodity taxes, indirect taxes, imports and exports in that order.

Card 8; FORMAT (I3, F10.0)

This data is not required for operation in the normal running of the program, and this card should be inserted with an integer of less than -1 in the first field to cause the program to jump this step.

Cards 9 - FORMAT (6 (2I3, F7.3))

These cards contain the input and output information for the new sector. For any format group, the first integer field contains the row number, the second the column number and the real field the actual value of the entry. Note that every card in this group should contain a full six fields of data, even if the last card has to repeat some earlier input to achieve this.

3. Running the Program

1. Decide whether either KAL or KAT contain applicable consolidation and matrices. If so, use the editor to alter the sectoral information and option selectors on the first two lines to suit requirements. If not, punch up relevant sectoral and optional data, followed by the required K* matrix.

---

* The consolidation matrix

2. If a new sector is to be imputed, punch up the required information.

3. Using the control language applicable to the ANU UNIVAC 1108, the following instructions and data would be run;

(1) @ ASG, AX AGGDAT - assign data file

(2) @ USE 8, AGGDAT - read from Unit 8.

(3) @ ASG, UP (filename) - assign read or write file

(4) @ USE 9, (filename) - read from or write to Unit 9

(5) @ ASG, AX (KAL or KAT)- only if KAL or KAT are to be used.

(6) @ ASG, AX AG - assign main program

(7) @ XQT AG. ABS - execute main program

(8) @ ADD (KAL or KAT) -

OR

Enter sectoral and options cards, followed by K matrix cards

(9) Enter new sector data if required.

(10) @ FIN - finish

4. Output

1. Provided variable ICOEF is set to one in the data the words 'USES FLOW MATRIX' will be printed out.

2. Provided IALG has been set to one, the words 'NO ALGORITHM' will be printed out.

3. The sector numbers for which multipliers are to be calculated, entered as elements in the ISUBS vector in the data, will be printed out.

4. The values for NO, M, MSR, ICOEF, IALG, IMPUT, NUM, NEWM will be printed out in line.

5. Wherever the statement 'CALL PRMAT* (etc) appears in the program, the matrix given as the third argument in the call statement list will be printed out by columns.

*See section 6 of this appendix for details.

6. The amounts of generated effect (in $m) for each sector and multiplier type are printed out. These figures are converted to whichever multiplier is required (see section 2 of the main report) by dividing by the appropriate direct input or total output figures. Also printed out in this result matrix will be 'INVERSE TEST' results, and 'WEIGHTED LABOUR COEFFICIENTS' (the latter are explained in section 4 of the main report (see table 3)). Inverse test results arise from the pre-multiplication of the final demand vector by the relevant rows of the inverse matrix, According to standard input-output theory, such a process should give the total-output for the sector corresponding to the row used in the multiplications. Thus, when an aggregated matrix is being used, the figures so derived can be checked against the actual total output figures, as a test of the accuracy of the aggregation.

7. A figure for each sector under the heading 'OUTPUT GENERATED' will be printed out. This figure is not relevant to multiplier analysis.

8. A figure for each sector under the heading 'COLUMN TOTALS FOR THIS SET' will be printed out. If the program is using the error calculation sequence, this figure will be the sum of percentage errors (÷ 100) for all the multipliers in the sector column. (errors being the deviation of each figures from their counterparts on Unit 9). If the program is not using the error calculation sequence, the figures printed out under this heading will be meaningless.

5. Input Variables

LAB - Wage payments vector

TOT - Total outputs vector

FD - Final demand vector.

CTAX - Commodity tax vector

ATAX - Indirect taxes vector.

AIMPS - Imputs vector.

X - Exports vector

Note: These vectors have 105 elements in data file AGGDAT, and are returned from subroutine CONS with M vectors.

NE - No. of sectors for which multipliers are to be calculated (maximum of 9).

ISUBS - Vector of (NE) elements, giving the subscript number of each sector for which multipliers are to be calculated.

NO - No. of sectors in original matrix (105 if the AGGDAT file is to be used).

M - No. of sectors in the aggregated model (e.g. 51 if K-matrix KAT was used as the consolidation matrix).

MSR - Maximum No. of sectors allowed in aggregation (always equals No above)

A - The input output matrix. Depending where it appears in the program, this matrix may be in flow or coefficient form, and may be of dimensions (No X No) or (M X M).

ICOEF)
IALG)
IMPUT) Option flags (see section 2 above)
NUM)
NEWM)

AN)
B)
C) Multiplier effects vectors read from Unit 9.
D)
E)
WA)

J - Location of a column in A to be multiplied by a constant.

Z - Constant applied to a nominated column in A.

(Note that if J is set to less than zero, this step is jumped in the program).

6. Output Variables.

LABO - Multiplied Wage payments effects vector.

ATEST - Inverse test vector

CTAKA - Multiplied commodity taxes vector.

ATAXA - " indirect taxes "

AIMP - " imports "

XE - " exports "

ED - Weighted labour coefficients vector

IMSAV - Output generated vector.

7. Subroutines

S.1. CONS - Reads in the K matrix, which is a rectangular matrix consisting of ones and zeroes, and of dimensions MSRXM. This consolidation matrix is post-multiplied by matrix A to produce the square matrix of dimensions M x M, and this aggregated matrix is returned as A. The K matrix is also post multiplied by the LAB, TOT, FD etc. vectors, to produce aggregated versions of these - and these are also returned to the main program under the same vector names.

Subroutine ALG,(S.3) a specialized aggregating algorithm is called by CONS if option IALG is set to zero.

S.4 PRMAT. - Can be called anywhere in the program to print out the A or IA matrices. The call statement:

CALL PRMAT (M1, M2, A, M3) will cause the matrix A to be printed out in column form, where:

M1 = No. of rows
M2 = No. of columns
M3 = Max No. of rows and columns:

Before aggregation:

M1 = M2 = M3 = MSR

After aggregation;

M1 = M2 = M.

M3= MSR.

S.5. LABA. Calculates the multiplied wage payments effects for the sectors nominated in vector ISUBS.

S.6 FUNCTION MAXY)
) Functions required by ALG.
S.7 FUNCTION MSIGN)

S.8 TEST. Applies the relevant rows of the inverted matrix (IA in the main program) to the final demand vector, to produce total output results (See explanation of 'INVERSE TEST' results in Section 4 of this appendix.)

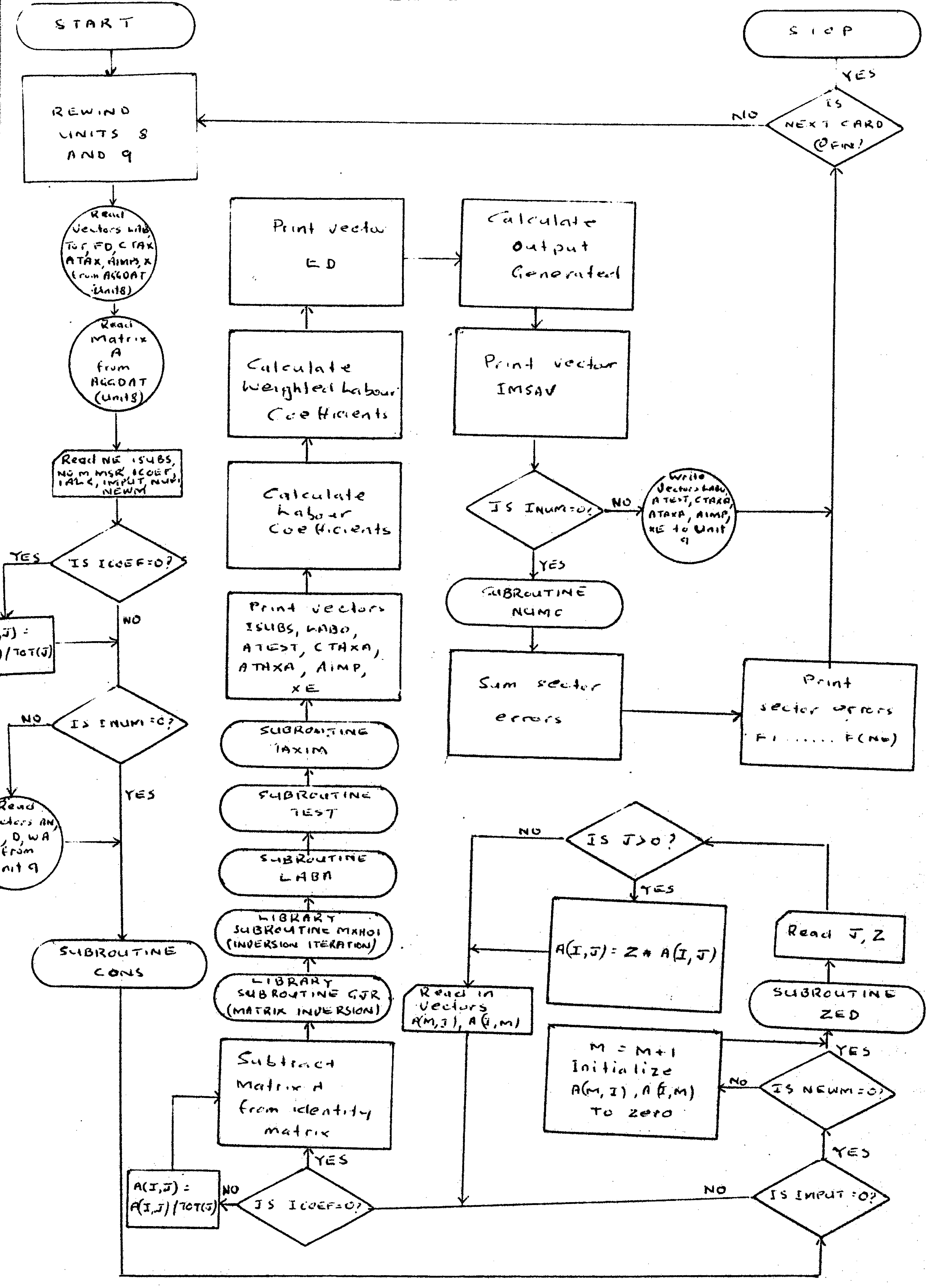
S.9. TAXIM. Performs the same operations as LABA above, but on the CTAX, ATAX and X vectors.

S.10 NUMO. Uses multiplier effects vectors read from Unit 9, and those calculated in LABA and TAXIM to compute errors.

S.11 ZED Reads card data, and places the real number into the factor input vector named in the argument list. The position for the insertion is nominated in the integer field preceding the real field. If an integer of less than one is encountered, the insertion procedure is not carried out. The subroutine must be called separately for each vector in which it is desired to insert a new element.

S.12 GJR)
)Relocatables only of library programs to invert
S.13 MXHOI)and iteratively improve the nominated matrix.

PROGRAM AG



START
REWIND UNITS 8 AND 9
Read Vectors LAB, TOT, FD, CTAX, ATAX, AIMP, X from AGGDAT (Unit 8)
Read Matrix A from AGGDAT (Unit 8)
Read NE ISUBS, NO M MSR ICOEF, IALC, IMPUT NUM, NEWM
IS ICOEF=0?
YES
NO
IS INUM=0?
NO
YES
from Unit 9
SUBROUTINE CONS
IS ICOEF=0?
NO
YES
A(I,J) = A(I,J)/TOT(J)
Subtract Matrix A from identity matrix
LIBRARY SUBROUTINE GJR (MATRIX INVERSION)
LIBRARY SUBROUTINE MXH01 (INVERSION ITERATION)
SUBROUTINE LABA
SUBROUTINE TEST
SUBROUTINE TAXIM
Print vectors ISUBS, LABO, ATEST, CTAXA, ATAXA, AIMP, XE
Calculate Labour Coefficients
Calculate Weighted Labour Coefficients
Print vector ED
Calculate Output Generated
Print vector IMSAV
IS INUM=0?
NO
YES
Write Vectors LABO, ATEST, CTAXA, ATAXA, AIMP, XE to Unit 9
SUBROUTINE NUMC
Sum sector errors
Print sector errors F1 ..... F(NE)
IS NEXT CARD @FIN?
YES
NO
STOP
IS IMPUT=0?
NO
YES
IS NEWM=0?
NO
YES
M = M+1 Initialize A(M,I), A(I,M) To zero
SUBROUTINE ZED
Read J, Z
IS J>0?
NO
YES
A(I,J) = Z * A(I,J)
Read in Vectors A(M,J), A(I,M)

APPENDIX E

DIAMETER DISTRIBUTION OF PINUS SAWLOGS, BATLOW SUB-DISTRICT

Table E1 below gives the expected underbark diameter distribution of plantation sawlogs from the Batlow Sub-district, for the period 1973-77, as collected from office records.

TABLE E1

EXPECTED UNDERBARK DIAMETER DISTRIBUTION

Diameter	Volume (Pre-war Plantations) in 000's s.ft.
6	247
7	391
8	587
9	833
10	1144
11	1521
12	1938
13	2367
14	2806
15	3157
16	3371
17	3477
18	3426
19	3124
20	2691
21	2246
22	1790
23	1347
24	978
25	680
26	447
27	267
28	135
29	59
30	21
31	9
32	3
33	1

APPENDIX F

FORESTRY COMMISSION RECORDS OF AVERAGE MILL DOOR LOG VALUES FOR THE MONTH OF MAY, 1972

TABLE F1

AVERAGE HARDWOOD MILL DOOR VALUES

District	Mill Door Log Value (Group B Medium Girth Logs) ($/m^3)
Casino	18.05
Coffs Harbour	15.42
Glen Innes	16.31
Kempsey	16.27
Newcastle	23.01
South Coast	21.78
South East	18.89
Taree	18.77
Wauchope	15.97
Metropolitan	26.78

AVERAGE: 19.06

EXTRACT FROM

THE AUSTRALIAN JOURNAL OF AGRICULTURAL ECONOMICS

The Journal of
The Australian Agricultural Economics Society

A NOTE ON THE USE OF A MODIFIED INPUT-OUTPUT MULTIPLIER FOR LAND USE EVALUATION*

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The modified input-output multiplier is proposed. Some limitations of the multiplier and the results of its application to four major land use industries are discussed.

Method

The input-output labour multiplier for an $m \times m$ matrix of industries that will be used in this note is given in equation 1:

$$(1) \qquad M_i^1 = \left(\sum_{j=1,\, j\neq i}^{m} [z_{ji}\, l_j] + l_i + \sum_{j=1,\, j\neq i}^{m} [z_{ij}\, l_j\, x_{jd}]\right) / l_i$$

where, M_i^1 = the modified labour multiplier for industry i.

l_j = the labour coefficient of industry j (i.e. labour cost in industry j/ total output of industry j).

l_i = the labour coefficient of industry i.

z_{ji} = the interdependence coefficient expressing output from industry j into industry i.

z_{ij} = the interdependence coefficient expressing output from industry i into industry j.

x_{jd} = the amount of output from industry j that goes directly to final demand/total output of industry j

This expression differs from conventional input-output multipliers in that it includes the labour performed in the processing industries attributable (on a per dollar of output basis) to input industry ij. Conceptually, the expression is similar to the basic-derivative employment mutliplier presented by Olson and Fischer [12]. Billings [9] has shown the mathematical identity of input-output and economic base multipliers in general.

In addition to the multiplier itself, a policy-maker may also want to know the types of labour generated directly and indirectly by a given industry. If $g_{j1}, g_{j2} \ldots g_{jn}$ are coefficients that express the proportions of skill groups l_1 to n that comprise the work force of industry j, then:

$$(2) \quad G_{is} = \left(\sum_{j=1,j\neq i}^{m} [z_{ji} L_j g_{js}] + L_i g_s + \sum_{j=1,j\neq i}^{m} [z_{ij} l_j x_{jd} g_{js}]\right) / L_i M_i^1$$

where G_{is} = the proportion of total labour generated by industry i that is classified as skill group s.

L_i, L_j = total labour used in industries i, j (in \$)

(All other terms as defined previously).

If the labour multiplier is to be used as an indicator of the economic stimulation caused by industry i, then the effect of the magnitude of labour coefficients on the labour multiplier has to be determined. One method of isolating this coefficient magnitude effect is by calculating the weighted average of labour coefficients of all industries, where the

* The author gratefully acknowledges the assistance of Mr E. D. Parkes, Department of Forestry, A.N.U., in the preparation of this paper.

weighting used is the significance[1] of each industry to the one being examined.

Let,

$$S = \sum_{j=1, j \neq s}^{m} [z_{ji} L_j]$$
$$P = \sum_{j=1, j \neq i}^{m} [z_{ij} l_j x_{jd}]$$

Now,

(3) $$ML_i = \{(S . \sum_{j=1, j \neq i}^{m} [z_{ji} l_j]) / \sum_{j=1, j \neq i}^{m} [z_{ji}] + (P . \sum_{j=1, j \neq i}^{m} [z_{ij} l_j] / \sum_{j=1, j \neq i}^{m} [z_{ij}])\} / (S + P)$$

where ML_i = the average of labour coefficients weighted by their significance to industry *i*.

(All other terms as defined previously)

Results and Conclusions

The processes outlined above were used to analyse the labour effects of four Australian land use industries; wool, wheat, meat cattle and forestry. In this analysis, the industry definitions are the same as those used in the 1962-63 Input-Output Tables [4]. The inter-industry coefficients used were those derived from the 1967-68 RAS updating [10] of the 1962-63 tables.

The labour coefficients of the three agricultural industries derived from the input-output table required some adjustment, because the table included owner-operator labour in gross operating surplus, rather than wages and salaries. To make the labour components of these industries comparable with that of forestry (which has virtually no owner-operator labour), owner-operator labour was transferred to wages and salaries. A major problem was encountered during transfer because the supplementary data sources, such as the BAE bulletins and Census and Statistics publications classified the agricultural industries differently to the input-output table. Where more than one commodity is produced on a single farm, the problem is intensified because the input-output table is set out on an industry/commodity basis, and therefore allows only one commodity to be produced by one industry. Thus, when BAE data for multiple-product farms were imputed into the input-output table, it was necessary firstly to sort the data into single commodity groups. The labour inputs were then calculated by allocating labour from the multiple product farm figures to the relevant commodity groups on a pro rata basis. Labour coefficients calculated in this way are given in column 2 of Table 1.

The labour multipliers calculated from equation 1 are given in column 3.

A better figure for comparison and planning is obtained by multiplying the labour coefficient by the labour multiplier. The result will give the labour generated, directly and indirectly, per dollar of input into the industry being examined. These labour/output figures are shown in column 4 of Table 1.

Column 5 of Table 1 gives the weighted average labour coefficients (equation 3) for the four industries.

[1] The significance, in this case, is taken to be in the order of inter-industry linkages between the industry in question, and all other industries. These can be read direct from the $(1 - A)^{-1}$ matrix.

TABLE 1
Labour Effects of Four Land Use Industries

Industry (1)	Labour Coefficients (2)	Labour Multiplier (3)	Labour/ output (2) x (3) (4)	Weighted average of Labour Coeff. (5)
Sheep	0·32	1·53	0·49	0·24
Wheat	0·16	2·25	0·36	0·25
Meat Cattle	0·31	1·87	0·58	0·25
Forestry	0·30	2·20	0·66	0·26

Table 2 gives the proportions of each of five skill groups employed directly in land-use industries in Australia.

TABLE 2
Skill Group Coefficients for the Major Australian Land Use Industries

Industry	Skill Groups				
	I	II	III	IV	V
Sheep	0·00	0·69	0·31	0·00	0·00
Wheat	0·00	0·78	0·22	0·00	0·00
Other Grains	0·00	0·66	0·33	0·01	0·00
Meat Cattle	0·00	0·61	0·39	0·00	0·00
Milk, Cattle & Pigs	0·00	0·71	0·29	0·00	0·00
Poultry	0·00	0·58	0·42	0·00	0·00
Other Crops	0·00	0·66	0·34	0·00	0·00
Forestry	0·03	0·37	0·59	0·01	0·00

Classification problems were again apparent in compiling these figures. The skill group classification used (see Appendix 1) was the one provided by the Tariff Board [14]. This classification is compatible with the input-output table in the secondary and tertiary divisions, but groups all the rural industries under the single heading, Agriculture. To rectify this, it was ncessary to inspect detailed records of occupational employment in rural industries held by the Bureau of Census and Statistics. The figures were then adjusted to conform with the input-output model using the procedure outlined above for derivation of labour inputs.

Table 3 gives the direct and indirect effects of the four industries on skill groups (equation 2).

TABLE 3
Direct and Indirect Effects of Four Land Use Industries on Skill Groups

Industry	Skill Groups				
	I	II	III	IV	V
Sheep	0·0096	0·5594	0·3805	0·0503	0·0001
Wheat	0·0235	0·4345	0·4144	0·1273	0·0003
Meat Cattle	0·0218	0·3928	0·4642	0·1209	0·0002
Forestry	0·0313	0·2348	0·6134	0·1203	0·0002

Before progressing to conclusions, some of the limitations of this analysis need to be discussed. Firstly, there is the general limitation of all input-output models; the exclusive use of linear functions. Many of the assumptions implicit in the relationships described above depend on this fact. Changes in technology, diminishing and increasing returns to scale and similar factors are ignored. For this reason, it is important that any analyses using this method should be based on recent data, and that any large-scale changes predicted by the model be verified by other means where possible.

The second limitation is more specific to the particular inter-industry system used in this analysis, and is a result of the aggregate nature of the figures. All data used are in national average terms and therefore should not be used for specific project evaluations. The findings should be regarded only as indicators of the nature and order of indirect effects that pertain to the industries examined.

Within the range of these limitations, some conclusions can, however, be drawn from the above results.

The most obvious feature is the marked difference in ranking that results from assessing total, as against only direct effects. This difference is clearly shown by comparing the figures from columns 2 and 3 of Table 1. It is paralleled by the disparity in equivalent skill group coefficients between Table 2 and Table 3. The order and nature of indirect effects is significant in the industries examined, and this fact has quite profound implications for decisions on land use being taken at the state or federal levels.

In terms of employment generation, the high labour/output figure for forestry and, to a lesser extent, meat cattle, indicates that these industries have a greater influence per dollar of output on the labour market than do the other industries. This argument can, in this case, be extended to suggesting that forestry and meat cattle also stimulate a higher degree of economic activity in the rest of the economy. The reason this inference can be drawn is that the weighted average labour coefficients (column 5, Table 1) for the four industries do not vary over a great range, while the labour/output figures do.

There is a wide range in the effects that the four industries exercise over the composition of the work force. It can be seen from Table 3 that forestry, for example, tends to cause a somewhat higher demand for sales workers, and a lower demand for clerical workers than do the other industries. Such facts as this are of interest to the planner, and are able to be compiled in Australia due to the availability of good data on occupation distribution and industry requirements.

Whether employment is regarded as a constraint or a factor to be maximized, it will usually exercise some influence over decisions being taken at governmental level. There would seem to be little point in nominating upper and/or lower limits to such a variable if there is no investigation of whether the limits can be met, both directly and indirectly. In the above analysis, only labour effects were considered. There seems to be no reason why the full effects of any decision on taxation and subsidy flows, import and export generation, population location and so on cannot be similarly investigated. Hopefully the results presented here will demonstrate that total, rather than only direct effects can be assessed, and that where large scale decisions are involved, should be assessed.

APPENDIX 1

Skill Group Classification

1. Professional, technical and related workers. Includes government administration and executive officials, some employers and workers on own account, pilots, flight engineers, etc.
2. Clerical and related workers. Includes draughtsmen and designers, precision instrument makers, etc., artists, etc.
3. Sales workers. Includes transport and communication workers, most production process workers, farm, mining and forestry workers.
4. Unskilled workers.
5. Unclassified.

The five major groups given here are the ones used in the Tariff Board skill group classification. A more detailed listing, including occupation codes from the Classification and Classified List of Occupations (7), is available from the Board.

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