ESTIMATING REGIONAL INPUT-OUTPUT MULTIPLIERS IN AUSTRALIA: A METHODOLOGICAL STUDY.

by

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STATEMENT

I hereby declare that this thesis is my own work and that,to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree or diploma of a university or other institute of higher learning, except where due reference is made in the text of the thesis.

P.J. Phibbs

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PREFACE

In order to avoid repetition of material, four papers written by the author are included in Appendix 1.

Three of these papers were written in conjunction with Dr. A. Holsman. These papers are based on analysis undertaken during the course of my research, and Dr. Holsman's involvement was limited to the traditional responsibilities of a supervisor.

ABSTRACT

The objectives of this study are to review the existing methodologies for estimating regional input-output multipliers, test the regional input-output model, and recommend changes to multiplier estimation techniques if appropriate.

The study reveals that the input-ouput model, after a number of adjustments are made to its structure, can produce accurate estimates of regional impacts. This conclusion provides support for a model that has achieved widespread use, but little rigorous empirical testing.

Secondly, the study concludes that there is no one preferred method for generating regional input-output tables in orderto generate multipliers. A GRIT-type model is considered the preferred alternative, but the final specifications of the model depend on the amount of data that needs to be acquired by survey. It is suggested that the amount of survey work necessary depends on a number of factors, including:

- the amount of available published data;
- the type of region being examined;
- the number and type of industries being analysed.

It is considered that use of survey-based sum of intermediate coefficients is a cost-efficient data gathering technique.

The third major finding of the thesis is that the accuracy of impact forecasts are improved if Service sector impacts are estimated using a simple Service employment-population model, rather than the traditional input-output model. In order to achieve consistency in impact forecasts, it is necessary tonest this Service employment-population model within a demo-economic model.

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CHAPTER 1

INTRODUCTION

The economic impact of either adding (or deleting) an economic activity in a region has long been of special interest to both people living in the region and to policy makers. With unemployment in Australia recently reaching record post-war levels, the importance of identifying the economic impacts associated with the introduction or removal of an employment source has been considerably increased.

Economists, geographers and regional scientists have responded to this interest in economic impacts by developing, over the last thirty years, a number of techniques for assessing regional economic impacts. These techniques can be conveniently divided into four categories[1]:

(1) Economic Base models;

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[1] A reasonable summary of these techniques, especially Keynesian and export base models, is contained in Phibbs (1980). For a discussion of econometric models see Glickman (1977).

(2) Keynesian multiplier models;

(3) Regional econometric models;

(4) Regional input-output models.

Regional input-output models are an extension of the application of the input-output model at the national level that was pioneered by Leontief (1936). They have enjoyed a rapid rise to prominence and are now generally acknowledged amongst regional scientists as being the the most powerful and comprehensive models available to the regional analyst. An apt summary of the importance of regional input-output analysis is provided by Conway (1977,197) who describes input-output models as:-

> "the most operational regional economic forecasting and planning tools of a general equilibrium nature"

Recognising this importance, this thesis is concerned with the development and application of regional input-output models. In particular the thesis is concerned with improving the usefulness of input-output models for regional impact analysis. In order to accomplish this aim, the thesis addresses itself to three major tasks.

The first task is the evaluation of a number of methodologies for generating regional input-output multipliers. During recent years there has been considerable debate on the most suitable method for generating regional multipliers[2]. This methodological debate, acknowledging the data ravenous nature of input output models (Isard and Langford, 1971), focuses on the trade off between cost and accuracy associated with survey and semi-survey methods for compiling input-output tables. The thesis surveys this debate and assesses the relative merits of the various methods which have been proposed and/or applied to date. This task is undertaken in Chapters Two and Three.

Secondly, the thesis is concerned with testing the regional input output model. Despite its widespread application over the last 25 years, to the author's knowledge the model has never been the subject of a rigorous empirical test. Whilst the complexities of regional economies make an uncontaminated "laboratory" test of the model impossible, an attempt is made in this thesis to test the model by adopting a "next-best" procedure (Chapter 4). The model is used to forecast employment changes in the Broken Hill region of New South Wales, Australia. Broken Hill is a large mining town situated on the western plains of the state, and which had an estimated population in 1982 of 27700. The Broken Hill region is eminently suitable for such a test since its economy is dominated by one sector - the mining sector. Moreover, the mining sector experienced a sharp reduction

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2 A reasonable summary of this debate is contained in Round (1983), Miernyk (1976) and Morrrison and Smith (1974).

in employment in 1973 as a result of the closure of the Broken Hill South mine. A total of 873 jobs in the mining sector were lost, resulting in a 17 percent decrease in employment in that sector. An input-output table for Broken Hill is generated using a technique derived from the methodological evaluation of Chapters 2 and 3, and an employment multiplier is generated for the mining sector. The resultant multiplier is used to forecast the likely short-term changes in the city's employment as a result of the downturn in the mining sector. These forecast changes in employment are compared with actual changes in employment reported by the 1976 Census, and the discrepancies are described and analysed.

The third task of the thesis is to recommend changes to the input-output model on the basis of the testing of the input-output model in Chapter 4 (Chapters 5 and 6). Chapter 5 focusses on the development of an alternative methodology for forecasting changes in selected types of service sector employment. It is proposed that service sector flow-ons should be estimated using a simple service sector-population model. This model is specified and tested in Chapter 5. The service sector-population model is then integrated into an input-output framework by constructing a demographic-economic regional impact model which is presented in Chapter 6. This model is then used to forecast the impact of a new coal mine at Mudgee, a small shire in the Central-West of New South Wales.

It should be noted that the title of the thesis specifically refers to Australia. The aim of this strategy is to explicitly state that the thesis is concerned with the application of regional input-output models under Australian conditions. There are three reasons why such a country-specific stance is necessary.

Firstly, the data ravenous nature of input-output models means that the construction of input-output tables is facilitated by the availability of published data. Indeed, this is such a crucial factor that methods for generating regional input-output tables, which are dependant on the availability of published data and developed in one country, may not be feasible in other countries for which similar data are not available. For example, the non-survey method of Stevens _et al_ (1983), which depends heavily on data on transport costs, would not be feasible in Australia where the transport data required to replicate the Stevens _et al_ method is unavailable.

In particular, in Australia there is a scarcity of published private consumption data. The only survey-based consumption data collected by the Australian Bureau of Statistics, the national statistical agency, is an irregular series last collected in 1975-76. This paucity of consumption data means that methods that minimise the importance of the private consumption coefficients are especially appropriate in the Australian context. This point is re-examined in the discussion of the service employment-population model in Chapter 6.

This thesis acknowledges the variation in the availability of published data between countries and the impact this has on the implementation of the various methods for generating input-output multipliers. The evaluation of methodologies in Chapter Two assesses the feasibilty of various methods in the light of the available Australian published data.

The second consideration necessitating the adoption of a country-specific stance relates to the question of scale. The low population density of the Australian continent[3] means that the planning regions in Australia, usually those defined by State Governments, have by international standards, very small populations.[4] This means that in most cases applications of regional input-output analysis in Australia involve regional economies many times smaller than those overseas that have been the subject of similar studies. The Australian regions are not only many times smaller but in addition the economies are simple in nature and characterised by large leakages to the major metropolitan regions. In most non-metropolitan regions,

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[3] The gross population density of Australia in 1980 was 5 persons per square mile compared with 594 persons per square mile in the United Kingdom and 61 persons per square mile in the United States.

[4] The only exceptions to this rule would be the metropolitan regions of the two largest States, New South Wales and Victoria.

manufacturing activity is usually limited to the processing of rural commodities (Jensen and West, 1983). This means that the multiplier values in Australia will be largely dependent on the size of the direct coefficients of the activity under consideration.

Thus methodologies for generating input-output multipliers which may be inappropriate for the large complex regions of many Western countries may be quite feasible and appropriate in the Australian context. For example, the short-cut method for estimating final demand multipliers suggested by Phibbs and Holsman (1981) is not likely to be accurate in large, complex regions. However, it generates reasonable accurate final demand multiplier estimates for small Australian regions.

Moreover, the question of scale is reinforced by the concentration in this thesis on non-metropolitan regions. This focus is based on the view that non-metropolitan regions in Australia are by far the most important study areas for impact analysis. Policy makers, researchers and the community at large tend to be less concerned with impacts within the metropolitan capital cities, since the impact of any particular economic change tends to be dissipated in the remainder of the city's economy. For example, the loss of 500 jobs has a relatively minor impact in a city of 3 million people , but the loss of the same number of jobs in a region of 50,000 persons has a significant imapct and inevitably generates a large amount of community and political concern. As a result, the evaluation of methods in

Chapter Two is biased towards assessing the suitability of methods for generating input-output multipliers for non-metropolitan regions.

Finally, placing the thesis in an Australian context helps define the type of input-output model that will be examined.It is emphasized that the diffusion of input-output models in Australia has been considerably slower than elsewhere. The first national table (for the 1958-59 financial year) was not published until 1964 (C.B.C.S., 1964), whilst major regional studies did not appear until the mid-seventies(See, for example, Jensen, 1976;Mandeville and Powell,1976). The more complex models of the input-output family, such as the dynamic interregional models, have yet to receive widespread application in Australia. [5] The predominance of the simple static input-output model is also related to the structure of the Australian economy. The relatively simple nature of most regional economies means that in the majority of cases, interregional feedbacks are likely to be fairly small and hence the improvement in accuracy of the more complex models may not warrant the extra resources required to construct these models. In any case, the predominant emphasis on the simple model in Australia justifies the concentration on this type of model in the research presented here.

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[5] The exception to this general trend has been the recent development of an interregional model for Queensland (Morrison et al,1982).

CHAPTER TWO.

REVIEW AND EVALUATION OF TECHNIQUES FOR GENERATING REGIONAL INPUT-OUTPUT MULTIPLIERS

2.1 INTRODUCTION - THE UNSUITABILITY OF SURVEY-BASED TABLES

The earliest regional input-output tables depended on the use of unadjusted national input coefficients as approximations for regional coefficients (see, for example, Isard,1951,1953; and Isard and Kuenne,1953). The studies were superseded by "genuine" regional tables as regional input-output analysis developed into a major research area. The "genuine" tables were based on a survey approach and are regarded by many as the classic studies of input-output research (Hirsch,1959; Miernyk *et al*,1967; Miernyk *et al*,1970; and Isard and Langford,1971).

However, it soon became apparent to regional scientists that the construction of survey-based tables required substantial resources. Isard and Langford (1971;54) describe this problem with particular clarity:-

> "Input-output studies are without question among the most data ravenous economic models

> that have been developed"

Input-output studies, even for small regions, are very costly. For example, in an Australian context, Cutbush (1973) reported that Jensen's survey based input-output study of Central Queensland (total population 100,000 persons) cost $30,000 to complete in 1973. Thus it was not surprising that Jensen (1975;16), at the completion of his study commented that:-

> "The cost-effectiveness of conventional input-output analysis at the regional level in Australia deserves examination; more cost-effective alternative approaches to conventional input-output analysis and to impact analysis are available and may be sufficient for most policy-oriented research of this type in Australia"

In addition to the problems related to data gathering, the survey approach has a number of other weaknesses which generate errors in survey-based tables. The first of these relates to the quality of the survey process itself and is well summarised by Boster and Martin (1975;35):-

> "Poorly drawn samples, sampling errors, inadequate or poorly trained field workers, and poorly conceived schedules are among possible sources of error"

An empirical example of this problem is provided by Walderhaug (1972) who derived a 27 sector input-output table for the economy of the State of Washington, U.S.A. from the national table. Walderhaug found that the difference between coefficients from the derived table and those from a survey-based table was significant for 14 of the sectors. Moreover, he ascertained that for six of the fourteen sectors, the difference was the result of questionable sample data.

A second problem of survey-based input-output tables is the time they take to compile. The data-gathering commonly takes so long to complete that the resultant tables are usually well out of date by the time of publication. Schaffer and Chu (1969;83) considered that, as a result of this time lag, the published models "have little more than pedagogical value to their readers". Some examples will help illustrate this problem. Jensen's (1976) survey-based table of Central Queensland for the years 1965-66 was completed in 1976, the same year as Mandeville and Powell's (1976) survey-based model of the Central Macquarie Region for 1968-69.

As a result of these problems, survey-based tables have been viewed with increasing scepticism. Jensen (19812;13) captures the essence of this view:-

> "The day of the large survey-based table ...... has virtually passed. These tables are expensive; completion normally requires

> several man-years of work, which in turn usually absorbs a team of researchers involved in painstaking search for detail. This inevitable expense will almost certainly place the large survey-based table beyond the means of most research institutions and beyond the inclinations of those who frame the budgets of the sources of research finance."

This disillusionment with survey-based tables led to a search for alternative methods for generating regional input-output multipliers.

The search has proceeded in four main directions:-

(a) Manipulation of national input-output tables to generate regional tables using non-survey techniques.

(b) Simplification of regional input-output tables with the aim of reducing the data requirements of the model.

(c) Semi-survey techniques for which limited surveys are undertaken within a region.

(d) Use of short-cut formulae to estimate regional multipliers.

This Chapter reviews each of these approaches. By way of introduction, the first section reviews the criteria that should be used in evaluating techniques. Against this background, the second section evaluates non-survey techniques, whilst the third section considers the "simplification of input-output tables" approach. The fourth section evaluates the semi-survey approach. Included in this section is a review of a number of simulation studies, examining the relationship between errors within the input-output table and multiplier error. The last section assesses the most recent class of alternative methods - the short-cut formulae approach.

2.2 CRITERIA FOR EVALUATING INPUT-OUTPUT METHODOLOGIES

The criteria for evaluating alternative methods for deriving regional input-output multipliers are conceptually fairly simple. The method must be able to produce reasonably accurate regional input-output multipliers at a reasonable cost. It should be stressed that since this thesis is concerned with regional impact analysis, methods will be judged on their ability to produce accurate multipliers, rather than input-output tables[1]

[1]. The task of generating input-output tables that contain accurate entries for each cell- what Jensen (1980a) refers to as partitive accuracy- is a daunting one, and is not directly addressed in this thesis.

as such.

However, the problem remains of operationalising the above guidelines. Firstly, the phrase "reasonably accurate" multiplier has to be defined. Since in most cases the true multiplier is never known, a surrogate benchmark must be developed to evaluate multipliers generated by alternative methods. Traditionally, multipliers derived using alternative methodologies have been compared with multipliers generated by survey-based tables. However, for the reasons discussed earlier in this Chapter, some survey-based tables themselves contain errors, which may make such a comparison misleading. Unfortunately, no other method of evaluation is available so one can only agree with Cartwright's _et al_ (1981,41) views on the problem:-

> "It is necessary to adopt some norm against which to compare the alternative techniques, and the survey-based tables are the most generally accepted basis for comparison"

Therefore, for the purposes of evaluation, a reasonable level of accuracy is defined as a reasonable level of accuracy in comparison with survey-based tables.[2] However, where possible

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[2]. Such a position would be much harder to justify if a cell-by-cell comparison of the tables was required, rather than a comparison of multiplier values.

such a comparison should meet the following condition. The construction of the survey-based tables should be critically examined and likely weaknesses - such as poor response rates in certain sectors - should be noted. In some cases, certain elements of the survey-based tables may have to be changed in order to facilitate comparison.

Specifying the level of accuracy considered to be reasonable presents further problems since a subjective judgement is obviously required. Nevertheless, in the light of comments by those practitioners concerned with impact studies in both the public and private sector, a reasonable level of accuracy is defined as the ability to generate multipliers within 15 percent of those generated by good survey-based estimates, where percent error is defined as follows:-

$$E = (M_{am} / M_s) \times 100 \qquad \text{........} \quad 2.1$$

where E = percent error

M_{am} = the multiplier estimate of the alternative method

M_s = the survey-based multiplier

2.3 NON-SURVEY METHODS

A variety of non-survey techniques have been developed to convert national input-output tables into regional tables. The methods are variations of two main approaches, namely the location quotient approach and the supply-demand pool technique.

The basic location quotient approach consists of a measure to estimate regional imports. The location quotient (LQ) is an index which compares the relative importance (usually in terms of output, earnings or employment) of an industry in a region, to its relative importance in the nation. The traditional formula for the location quotient, with output being the measure of importance, is:

$$LQ_j = \frac{X_j^r / X^r}{X_j^n / X^n} \qquad \text{.........2.2}$$

where LQ_j = the location quotient for sector j

X = output

r = region

n = nation

In using the location quotient to convert national to regional input-output tables the following procedure is adopted:- If the LQ is greater than 1 for a given sector, then the national coefficients are used in the regional table, whereas if the LQ for a given sector is less than 1, the regional coefficients for the row corresponding to that sector are estimated by multiplying the national coefficients by the LQ.

Several more sophisticated versions of the LQ approach have been developed. These include:-

(a) Purchases only LQ: this was originally suggested by Tiebout (1969) who recommended that the summation of the total output in calculation of the quotient for industry i should be carried out only over those industries that make purchases from industry i.

(b) Cross Industry LQ (CILQ): The CILQ (Leven,1964) attempts to take into account the relative local importance of the purchasing industry as well as the selling industry. Thus the CILQ compares the proportion of the national output of the selling industry i in the region, to the proportion for purchasing industry j, or:-

$$CILQ_j = \frac{X_i^r / X_i^n}{X_j^r / X_j^n} \qquad .....2.3$$

(c) Logarithmic Cross-Industry Location Quotient(LCILQ): This technique, which according to Round (1972) refines the CILQ by taking into consideration the relative size of the region compared to the nation, takes the form:-

$$LCILQ = \frac{q_i^L}{\log_2(1+q_j^L)} \qquad .....2.4$$

where q_i^L = location quotient of selling industry i
q_j^L = location quotient of purchasing industry j

The supply demand-pool technique - the other major non-survey approach - was proposed by Schaffer and Chu (1969) and is based upon regional commodity balances which were first derived by Isard (1953). This method relies upon subtracting total regional requirements from total regional output in each industry to obtain a net surplus or deficit. If a surplus is obtained for industry i, then local supply is sufficient to cover local demand and the national coefficients may be used in row i of the regional coefficients matrix. If however, a deficit is obtained, the implication is that local demand is greater than local supply and importation of goods and services from other regions will be necessary. In this situation the national coefficients of row i are reduced, i.e.

$$r_{ij} = a_{ij}.X_i^r/(\Sigma_j X_j^r.a_{ij}) \qquad \text{......2.5}$$

where r_{ij} = regional coefficients
a_{ij} = national coefficients

EVALUATING THE NON-SURVEY METHOD

Two major studies have been undertaken which evaluate the accuracy of non-survey methods. The first study, undertaken by Schaffer and Chu (1969), used the 1963 survey-based

Washington table to compare input-output tables and multipliers generated using location quotient techniques and the supply-demand pool technique. Their comparisons of survey-based and non-survey multipliers are summarised in Table 2.1.

TABLE 2.1. SCHAFFER AND CHU'S COMPARISON OF SURVEY AND NON-SURVEY INCOME MULTIPLIERS.

	Mean Income Multipliers	
	Type I	Type II
Survey	1.365	2.262
Simple LQ	1.658	3.329
Cross Industry LQ	1.887	3.444
Supply-Demand Pool	1.669	3.353

Source:- Schaffer and Chu(1969) Table 3,p96

These results, which show large discrepancies between survey-based and non-survey multipliers, and other comparisons between survey and non-survey tables led Schaffer and Chu (1969;96) to conclude that:- "there is still no acceptable substitute for a good survey-based study"

The second major evaluative study, that by Morrison and Smith (1974), compared multipliers derived using non-survey methods with those from a survey-based table for Peterborough, England. The results are summarised in Table 2.2.

TABLE 2.2 MORRISON AND SMITH'S COMPARISON OF SURVEY AND NON-SURVEY MULTIPLIERS

	Mean Output Multiplier		Mean Income Multiplier	
	Type I	Type II	Type I	Type II
Survey	1.090	1.521	1.133	1.299
Simple LQ	1.278	1.974	1.361	1.654
Cross Industry LQ	1.361	2.107	1.460	1.674
Logarithmic CILQ	1.343	2.080	1.442	1.819
Supply-Demand Pool	1.365	2.144	1.477	1.882

Source: Morrison and Smith(1974)

In general, the results support the findings of Schaffer and Chu (1969). The simple location quotient stands out as the best of the non-survey methods, but the percentage error between multipliers derived using this method and survey-based multipliers are substantial and certainly preclude the non-survey methods from being regarded as acceptable alternative methods. The Peterborough simulations were more accurate than their Washington counterparts, which Morrison and Smith (1974) attribute to differences in the accuracy of the two national tables. While this may have been a contributing factor, the differences may also be related to the differences in the size of the two regions. The population of Peterborough at the time of the study was about 83000, whereas the corresponding figure for the State of Washington was 2.9 million. For smaller regions, where there would be a large number of zero entries in the input-output table (over half of the entries in the Peterborough table were zero entries), the non-survey tables are likely to be more accurate. This is because the location quotient technique, in response to a zero output in any sector, is able to accurately predict zero entries.

Subsequent research into the accuracy of non-survey methods, has confirmed the results of the two earlier evaluation studies. Kipnis (1976), Latham and Montgomery (1979), Eskelinen and Suorsa (1980), Harrigan et al (1980) and Phibbs and Holsman (1982) have all demonstrated that large discrepancies exist between survey-based multipliers and those derived from non-survey tables.

A common finding of these studies is that non-survey techniques generate multipliers that are larger than their survey-based counterparts. In other words, non-survey methods tend to overstate the linkages between industries within an area, and hence to understate the amount of leakage from the local economy. This overstatement is related to the non-survey methods' major theoretical weakness -their implicit assumption of maximum local trade[3].

For example, the simple location quotient method assumes that intraregional trade can be modelled using a ratio of regional output (or some other economic parameter) to its national equivalent. However, just because an industry which supplies inputs to sector j at the national level is located in a region, it does not necessarily follow that intraregional trade will occur. In reality, cross-hauling takes place. Thus an industry i will export goods from the region and firms in the same industry from outside the area will send goods into the region. This apparently irrational behaviour is sometimes related to the relative quality of the goods produced, where goods from outside the region are preferred because of price or quality. In this case, cross-hauling of similar goods actually occurs. This phenomenon could be called real cross-hauling.

However, often the cross-hauling problem is essentially a classification problem. Although firms might be classified in the same industry, their final products may be markedly different. This means that although industry i in a region might require inputs from industry j, that is well represented in the region, industry j may produce goods that are not suitable for

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[3]. For a review of the problems associated with the location quotient techniques see Isard (1960).

inclusion as an input. An example of this second type of cross-hauling will help clarify the situation. The Lithgow region in New South Wales was recently experiencing substantial growth as a result of large scale coal development. A major cement works is sited within the same region, and since cement is a major construction material it seems obvious that the cement works could expect a major boost in business as a result of the coal development. Nevertheless, on being questioned about the likely impact of growth in the mining sector, the manager of the cement works reported that the output of the plant would not be affected, since the coal mines required a special type of cement not produced at the plant. In this case it would appear that cement is being cross-hauled, but the cross-hauling is being generated by the classification system. If cement was classified into two types - type A produced in Lithgow, and type B required by the coal mines - then the cross-hauling problem would be eliminated. The cross-hauling generated by the aggregation problem could be called apparent cross-hauling. The degree of apparent cross-hauling is obviously related to the aggregation level of the industry classification used in the parent input-output table - usually the national table.

A central question in passing final judgement on the non-survey techniques is the relative size of the cross-hauling error components. If real cross-hauling is the larger component, then even the use of a very detailed classification system in the parent tables will generate large multiplier errors and render non-survey methods based on the location quotient approach unsuitable for generating regional multipliers. If the reverse is true, the availability of a detailed classification system would considerably enhance the power of non-survey techniques.

An indirect way of resolving this problem is to examine the level of aggregation of the national tables used in previous applications of non-survey methods, and compare aggregation levels with multiplier errors. This is done in Table 2.3.

TABLE 2.3 NUMBER OF INDUSTRIES IN THE NATIONAL TABLE AND MULTIPLIER ERROR FOR THE NON-SURVEY EVALUATION STUDIES.

Study	Number of industries in the national table	Absolute Mean Proportional Error-Type I Output Multiplier[a]
Schaffer & Chu (1969)	77	Not calculated
Morrison & Smith (1974)	71	.172
Latham & Montgomery (1979)	77	.239
Harrigan *et al* (1980)	48	.250
Phibbs & Holsman (1982)	109	.126

(a) Absolute Mean Proportional error is equal to:-

$$|(\text{SLQ multiplier}/\text{Survey multiplier} - 1)|.1/n$$

where n is the number of sectors

Source: Compiled by author.

The most striking feature of the table is that it shows that the largest multiplier error is associated with the national table with the smallest number of sectors, whilst the smallest error is linked with the most disaggregated national table. This result suggests that perhaps the major component of cross-hauling error is apparent cross-hauling. This evidence is hardly convincing, however, since a variety of other factors may have influenced multiplier errors besides the level of aggregation. More substantial evidence of the dominance of apparent cross-hauling is provided in a recent study by Cartwright *et al* (1981) in which a non-survey method called RIMS II - an extension of the RIMS methodology discussed in Section 2.7, is used to generate multipliers which are then compared with from survey-based studies[4].

The methodology used in the study is based upon the simple location quotient but diverges in two major respects from previous quotient studies. Firstly, two different variables were used to calibrate the location quotient formula. Earnings data were used to calibrate the location quotient equation for industries that sell predominantly to intermediate demand,

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[4]. The original RIMS procedure did employ the location quotient but the major thrust of the method was related to the use of an econometric equation to calculate linkage effects. As a result the method is examined in the short-cut formulae section of this Chapter, Section 2.7.

while personal income based location quotients were used for industries that sell predominantly to final demand. Secondly, and more importantly, the 469 sector national input-output table for the U.S.A. was used to generate the regional tables. Whilst this table had been available previously, it was not employed in non-survey multiplier studies, since similarly disaggregated data were not available to calculate the location quotients. However, Cartwright et al had access to a special series of county earnings data at the 4 digit SIC level which enabled location quotients to be calculated for the 469 industries of the input-output table.

This data was used to generate output multipliers for three regions (Washington, Texas, and West Virginia) which were then compared with estimates derived from survey-based input-output tables for the three regions. The resultant mean error was only 5.5 percent over the three regions, a considerable improvement on previous studies. Moreover, output multipliers using 2 digit SIC earnings data were also calculated which effectively reduced the national input-output table to the small level of aggregation employed by Latham and Montgomery (1979), and Schaffer and Chu (1969). The resultant mean output multiplier of 24 percent, is consistent with the findings of previous studies (see Table 2.3).

Cartwright et al's research strongly suggest that the location quotient technique is a more accurate technique than the conclusions of previous research have suggested.

Their results indicate that apparent cross-hauling is a major error component in the traditional application of the location quotient technique, and therefore the accuracy of the technique is considerably enhanced when a detailed national input-output table is available. The findings of Cartwright *et al* are suppported by the recent work of Sawyer and Miller (1983). They conducted a number of experiments in regionalization of the national input-output table for the U.S.A., using the survey-based Washington State input-output table (Bourque and Conway,1977) as a benchmark. They conclude that:-

> "the present results also confirm those of Cartwright *et al* (1981) that SLQ approaches which reflect detailed regional product mixes lead to substantially better estimates of regional inverse coefficients and industry multipliers" (1983;1517).

Nevertheless, despite the increased potential of the location quotient technique suggested by these studies, data limitations in Australia still render the method an unsuitable generator of input-output multipliers.[5] The Australian

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[5]. Indeed, even in the U.S.A. limitations on access to the 4 digit SIC earnings data- at this stage it is only available to Bureau of Economic Analysis officers- restrict the applicability of the quotient approach.

national input-output table is only available for a maximum of 109 industries and at this level of aggregation, apparent cross-hauling will generate significant errors in any regional input-output table based on the location quotient approach (see, for example, Phibbs and Holsman,1982).

In summary, the non-survey methods have been shown to be questionable alternatives to survey methods for generating regional input-output tables.

2.4 SIMPLIFIED TABLE APPROACHES

A number of different methods based on the concept of simplifying input-output tables have been proposed. The purpose of each of these has been to significantly reduce the data requirements of the input-output model.

THE INTERSECTORAL FLOWS APPROACH.

This model was pioneered by Hansen and Tiebout (1963) in their study of the Californian economy. The basic difference in approach between this model and normal input-output analysis is that firms are asked to provide proportions of their <u>sales</u> to specified final demand setors and local industries, and no information on inputs is requested. The rationale for requesting a breakdown of sales rather than purchases is based on the assumption that firms are more familiar with the destination of their outputs than the origin of their inputs. Hansen and Tiebout (1963) devised special multiplier formulae to be used in conjunction with this model.

The model has received a considerable amount of criticism since its inception. For example, Jensen (1975:160) states:-

> "It is assumed that, since the sales estimates cannot be checked for consistency against the estimates of intersectoral purchases, these tables will be less accurate for prediction purposes".

Clapp (1977) has made a more serious criticism. He disputes the usefulness of intersectoral flows multipliers contending that an implicit assumption of intersectoral-flows analysis is, unlike input-output analysis, that final demand sectors cannot be varied independently.

However, the main criticism of the intersectoral-flows model would still appear to be the data problem. Even with the reduced data requirements, an enormous data gathering exercise is still required, and therefore the intersectoral-flows method would not appear to be an acceptable method for estimating regional multipliers at reasonable cost.

REDUCTION IN THE NUMBER OF SECTORS IN THE INPUT-OUTPUT TABLE.

A number of simplified table approaches are based on the principle of reducing the size of the input-output table. The first of these approaches, the Technique for Area Planning (TAP) developed by Bonner and Fahle (1967), divided the traditional input-output table into major sectors (for which data are collected individually) and into minor sectors. The data necessary for the construction of the transaction table were reduced by disregarding all transactions between minor sectors. The major sectors would include the leading sectors in the region in terms of size and growth rate and would automatically contain the main export industries.

Empirical testing by the authors demonstrated that in many cases multiplier values derived from tables generated by the method were close to estimates yielded by a comprehensive transactions table. However, Bonner and Fahle (1967) found that in some cases omitting interdependencies between the minor sectors resulted in an understatement of the sector multiplier values by as much as 25 percent. As a result, compensating adjustments to the household row and column were attempted. A simple collapsing of the minor-to-minor flows into the household row and column was found to result in a severe overstatement of the multiplier, since the procedure significantly increased the household sectors' propensity to spend locally. Therefore, the minor-to-minor flows were multiplied by a reduction factor prior to the collapsing procedure.

Davis (1978) applied TAP in assessing multiplier impacts for the Vancouver Metropolitan region, Canada, and compared the resultant multipliers with estimates derived from a traditional survey-based table. This procedure revealed an average percentage error of only 2.4 percent between TAP and the survey multipliers, an error well within the "reasonable accuracy" definition of 15 percent adopted in Section 2.2 of this chapter. Nevertheless, it should be noted that this test was performed using the survey-based table to establish the minor-to-minor sector flows and the minor-to-minor flows reduction factor. That is, the test is based on exact knowledge of the minor-to-minor flows, whereas the original formulation of TAP assumed that no knowledge of these flows was required. It is considered that to independently establish minor-to-minor sector flows, even in an aggregate form, would still represent a substantial data collection effort. Moreover, when this task is added to the task of collection data for the major sectors, then the economies of the TAP technique in the data collection area are more apparent than real.

The second technique based on reducing the size of the input-output table was proposed by Doeksen and Little (1968) who, after experimenting with the aggregation of input-output tables to a very small number of sectors, concluded that:-

> "When data and research funds are limited, a small aggregated model will yield multipliers for a specific sector which are similar or nearly identical to those

> obtained from a very large disaggregated model"(134).

However, Doeksen and Little's work contains a serious flaw that Richardson (1972) was quick to point out. Doeksen and Little aggregated already existing input-output tables into tables with fewer numbers of sectors. However, if the aggregate method was applied in the field, it would be very difficult to draw a sample from large heterogeneous sectors that did not result in a large amount of bias. One obvious solution to this problem would be to use a very large sample, but this would limit the resource saving advantages of the method. Thus, while from a theoretical standpoint the aggregation approach seems promising, the savings in data gathering costs, like the TAP technique, are likely to be more apparent than real.

Similar comments could be applied to other methodologies that could be listed under the "reduction in table size" heading. Davis (1976) suggests that his rectangular matrix method (RMM) reduces the data requirements needed to produce regional multipliers. The underlying assumption of this approach is that accuracy in the determination of sector multipliers is not significantly reduced by eliminating intersector/ final demand sales data and final payments purchase data from the usual input-output requirements. He summarises his model as follows (1976;20-21):-

> "In contrast with the data generally

> collected for constructing the square-transactions matrix of the standard input-output model, the rectangular [(m.n) transactions] .... matrix requires the following data for each of the n sectors:- (1) total current purchases form each of the m sectors and (2) total sales".

It is interesting to note that Davis's technique relies primarily on purchases data rather than on sales data as in the Hansen and Tiebout (1963) approach.

Since a rectangular matrix cannot be inverted, Davis generated indirect impacts using three alternative algebraic techniques. In order to test the model, Davis generated output multiplier values using his methods and compared them with survey-based estimates. The average mean percent errors for his preferred technique for generating indirect impacts, resulted in a 0.6 percent deviation from survey multipliers for the Vancouver region and 13.0 percent for Stockton, California. On the basis of these results, Davis concluded that his method represents a viable alternative to the existing input-output methods of sectoral multiplier construction.

On the evidence presented by Davis, this method does seem to be an improvement on traditional input-output survey-based tables. The rectangular structure means that the cost of gathering data is reduced, but again the question remains whether the reduction is sufficient to allow the method to meet the criteria outlined in Section 2.2 of this chapter. A priori it would seem that the RMM method would not meet these criteria, since a major data gathering exercise is still required. Data on purchases from each of the sectors in the table still has to be collected, although the smaller amount of data required for each firm would be likely to generate higher response rates than traditional input-output surveys.

A number of other problems are associated with the RMM approach. Firstly, purchase data from each of the n sectors is divided by total sales figures in order to generate input coefficients for each sector. However, total output of a sector in an input-output table is usually defined as sales plus change in stocks, plus any other operating revenue. Secondly, and more importantly, the approach has not undergone a rigorous test.The tests that Davis (1976) performed involved aggregation of an original square matrix constructed from both purchase and sales data. It could be argued that a less accurate rectangular transactions matrix would result if such a matrix was constructed from the purchase-only data as outlined in the description of the RMM technique.[6] A real test of the method would require an actual application of the technique in a region, including a survey to

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[6] Such a criticism is similar to Jensen's (1975) criticism of the intersectoral flows model.

obtain the necessary data. Such a test would better indicate the accuracy of the technique and also allow a comparison of the costs of the technique with traditional input-output methods.

Thirdly, Davis has only "tested" the method's accuracy in relation to output multipliers. The rectangular structure of the matrix is likely to generate much larger errors in the specification of income and employment multipliers. This is because the RMM method assumes that the ratio of indirect impacts between two aggregated sectors (for any round) is the same as the ratio of their direct impacts. This is a courageous assumption and is much more likely to cause errors when calculating scalar products of income and employment rather than the summations required to calculate output multipliers.

Similar comments are also appropriate for a more recent technique suggested by Davis (1978). This technique involves a combination of the TAP-RMM approaches. The major difference between this technique and the TAP method, is that data relating to the purchases of major sectors from minor sectors is reduced to only one sector. This reduces the data requirements of the model in comparison with each of its parents.

In summary, the techniques based on reducing the size of the input-output table do not appear to be viable alternatives to survey-based tables. The models by Davis, whilst interesting conceptually, are not supported by rigorous tests demonstrating accuracy comparisons for different types of multipliers, and their cost effectiveness in relation to traditional tables is not documented. This is because applications of these models have involved the manipulation of existing input-output tables rather than the construction of multipliers from a complete application of the reduced-table methods. Such an exercise is needed before any model can be seriously considered as a viable alternative to traditional methods.

2.5. SEMI-SURVEY METHODS

In Section 2.3 it is suggested that that non-survey tables in Australia are not a viable alternative to survey tables and that at least some survey components must be included in the input-output table in order to generate reasonably accurate input-output multipliers. In order to ascertain what elements of the input-output table are likely to have the most impact on multiplier accuracy - and hence priority in an input-output survey based on limited resources - a number of simulation studies have been undertaken over the last ten years. These tests have involved systematically changing various coefficients in the input-output table and examining the impact of these changes on multiplier values.

SIMULATION EXPERIMENTS

The first experiments were undertaken by Stevens and Trainer (1976) who generated hypothetical regional input-output matrices of various dimensions and calculated output and wage (or income) multipliers for each sector included. The individual matrices were then altered by the insertion of new coefficients drawn from a normal distribution whose mean was the original coefficient, and whose standard deviation was variously a nominal 10, 20, 30 or 40 percent of the original coefficient. Multipliers were recalculated and then compared with the "exact" solution. Stevens and Trainer concluded that the errors in the multipliers in regional input-output analysis:-

a) are caused much more by errors in the regional purchase coefficients than by errors in the technological coefficient;
b) can be reduced substantially by survey data for just the sectors impacted in the first round;
c) are quite sensitive to errors in household coefficients; and that
d) there is a significant negative correlation between multiplier error and matrix size.

A similar analysis was undertaken by Park _et al_ (1981). However, instead of generating random input-output tables at various levels of aggregation, experiments were conducted at the single level of aggregation, using a survey-based input-output table for Utah as a benchmark. The error matrix was applied to each component of the input-output table for error levels of 10, 20, 30 and 40 percent. Like Stevens and Trainer (1976) they concluded that errors in multipliers tend to be far more sensitive to errors in regional purchase coefficients than to errors in technical coefficients. Moreover, they estimated errors in individual sectors - a task not addressed by Stevens and Trainer - and concluded that the errors were proportional to the size of the sectoral outputs.

West and Jensen (1977) undertook a somewhat similar analysis but their study was more concerned with isolating the factors that generate multiplier instability. They used "shocking techniques" to examine the effects of proportional error in the direct coefficients on multiplier values. The assumed "true" or correct input-output table was a 26 sector model of the Central Queensland economy (Jensen, 1976). Errors were generated in non-zero coefficients of the table by the use of a random number generator, in a normal distribution, within the range 5 to 25 percent. Moreover, the errors were proportional with the magnitude of the error being related to the size of the coefficient. One hundred tables of coefficients incorporating these errors were generated. Conventional output and income multipliers were calculated for each of the one hundred generated tables of coefficients, and the distribution of each set of multipliers was examined to test the stability of the multipliers in the simulated error conditions.

The results of the analysis demonstrated that:-

(i) the instability of output multipliers varies directly with both the size of the multiplier and the extent to which individual coefficients dominate their respective columns in the technology matrix. Therefore, West and Jensen (1977) suggest that greater attention should be given to sectors showing larger multipliers, particularly if their columns are dominated by a relatively small number of cells.

(ii) the magnitude of errors with respect to income multipliers appears to be influenced by two factors, primarily the correlation between the column elements of the inverse and the household sector, and secondly, to a lesser extent, the size of the corresponding output multiplier.

In the same year, Burford and Katz (1977) reported some results of matrix generation experiments. The experiments involved generating random samples of 50 input-output matrices, where the matrix dimensions and the column totals - the sum of intermediate inputs - were fixed. For each set of 50 sample matrices, multipliers were computed, as well as mean vectors, variance vectors and vectors of minimum and maximum multipliers. For some sets of matrices, the column totals were set to equal column totals from existing input-output tables, and the resultant multipliers were compared with the survey-based values.

On the basis of this analysis, Burford and Katz (1977, 29) conclude that:-

> "the key determinants of the values of the multipliers are:- 1) the average value of the column total in the interindustry coefficient matrix and 2) the specific values of the individual column totals. The distribution of coefficient values in the columns has a relatively small role in determination of specific multiplier values, though multipliers do tend to be affected by the general coefficient structure within columns"

Jensen and West (1980) point out that Burford and Katz's findings contradict their earlier work (1977) and then go on to examine the effect of relative coefficient size on input-output multipliers. Fourteen empirical input-output models ranging from an Australian national model to small Queensland regional models were employed in the experiment. The experiment proceeded as follows:-

> "To obtain the <u>separate effects</u> of relative coefficient size, each five percentage interval of non-zero coefficients arranged in ascending order, was removed (set equal to zero). Multipliers were calculated and the coefficients replaced prior to removal of the next highest group of coefficients ....

Toobtain the cumulative effect of relative coefficient size, the non-zero coefficients in ascending order were removed progressively in five percentage class intervals. Multipliers were calculated in the conventional manner following the removal of each group of coefficients" (1980;660).

The calculated multipliers were compared with the "true" multipliers associated with the original regional tables. The results were interpreted as follows:-

"This paper provides some empirical suppport for the notion that the larger coefficients exert relatively more influence on multipliers; it also provides empirical support for an accuracy-maximising approach to multiplier derivation. This notion, implied in most operational circumstances and probably accepted generally by analysts, is that the budget resources available to the analyst should be directed to ensuring accuracy in the relatively large coefficients, and allocated in decreasing amounts to progressively smaller coefficients" (1980;668).

They also conclude, using mean intermediate coefficient sums per sector as their measure of interconnectedness, that:-

> "... that the larger coefficients are relatively more important in multiplier formulation in more connected tables than in less connected tables" (1980;668)

These results have been challenged by Hamilton (1979) who demonstrated, using regression analysis and the same fourteen tables used by Jensen and West (1980), that:-

> "change in coefficient sum seems to be the prime determinant of multiplier reduction and therefore absolute change in a large coefficient will have an impact on output multipliers about equal to the impact of the same change in a small coefficient" (1979; 16).

Hamilton contends that these findings imply that Jensen and West's rule of thumb of concentrating on larger coefficients is only valid if proportional errors occur in coefficients - that is, the largest errors occur in the largest coefficients. However, Hamilton argues that often the larger coefficients, since they represent important economic linkages, have been better studied in prior research and in studies of other areas. Hamilton then goes on to suggest that these important economic linkages can often be accurately quantified from readily available published data.

Hamilton then conducts his own simulation experiments, using absolute errors, to explore the relationship between absolute error and multiplier errors. He used 5 sector models for 11 of the tables used in the Jensen and West's paper. An error of .01 was applied to just one coefficient of the table and the output multipliers computed. This process was repeated until the error had been applied to every coefficient in the table. After each step, an error elasticity was computed, expressing the percent change in average output multiplier portion above unity divided by percent change in coefficient sum.

Hamilton concluded from the experiment that error elasticities are closely related to model interconnectedness. Moreover, the experiment showed that error elasticities varied depending on where the absolute error occured in the matrix. Hamilton used regression analysis in an attempt to explain the pattern in the error elasticity coefficients. The results revealed that:-

> "Output multipliers are more sensitive to coefficient errors of a given absolute size when the errors occur in rows with large coefficient totals and columns with large diagonal elements" (1979; 21).

Hamilton summarizes his findings by saying that if the input-output researcher accepts the absolute value hypothesis then attention must be devoted to:-

> "those coefficients where his <u>a priori</u> knowledge suggests that he can make the greatest absolute improvement. This needs only be adjusted to recognize the apparent importance of large row totals and large diagonal elements" (1979; 24)

The final simulation study (Phibbs and Holsman, 1982 - see Appendix 1) used a single input-output table for Evanston (Hooker and Potter, 1970) as a benchmark. Their simulation tests were designed to assess the usefulness of Burford and Katz's work on the importance of the sum of intermediate coefficients.

Their first test involved generating a number of random direct coefficient matrices, subject to the following constraints:-

a) the generated coefficient fell within a certain percentage range (from 10-100) of the corresponding coefficient from the Evanston table;

b) the coefficient was greater than zero; and

c) the sum of the generated intermediate coefficients for any sector was equal to the sum of intermediate coefficients for the corresponding sector of the Evanston table.

This generation process was repeated fifty times. The Leontief inverse was computed for each generation and the output and Type 1 income multipliers were caclulated. These multipliers were then compared with the published Evanston multipliers. The results of this analysis demonstrated that the generated output multipliers were in most cases good approximations of the published multipliers, even when the direct coefficients were allowed to vary by up to 100 percent. Nevertheless, some sectors experienced errors considerably larger than their counterparts. Three sectors in particular experienced consistently large errors. Two of these sectors had large sums of intermediate coefficients, and very large input coefficients for the wholesaling sector. The third sector had a smaller sum of intermediate coefficients but it is also characterized by a dominating wholesaling input coefficient.

Phibbs and Holsman's second simulation test (1982) was structured to examine the importance of direct coefficients in sectors for which no multipliers are calculated. For this test, the constraints varied between sectors.

For each set of random generations (with fifty generations per set) multipliers were calculated for sector j. For this sector, the following constraints applied:-

a) the generated coefficient fell within a 10 percent range of the corresponding coefficient from the Evanston table;

b) the coefficient was greater than zero;

c) the sum of the generated intermediate coefficients for any sector was equal to the sum of intermediate coefficients for the corresponding sector of the Evanston table.

For the other eighteen sectors, the constraints were:-

a) the generated coefficient fell within a certain percentage range (from 10-100%) of the corresponding coefficient from the Evanston table;

b) the coefficient was greater than zero.

This second simulation test revealed that the lower level of accuracy for the non-j sectors in the second simulation test had only a minimal impact on the accurcy of the multiplier estimates.

Thus, it is evident that the simulation tests to date have generated a number of important results that have implications for choosing a suitable semi-survey method for generating input-output multipliers. These are summarised as follows:-

1.(a) Regional purchase coefficients or the sum of intermediate inputs have an important bearing on multiplier accuracy. (Steven and Trainer,1976; Park *et al*,1981; Burford and Katz,1977; Phibbs and Holsman,1982; Hamilton, 1979).

(b) The importance of the sum of intermediate inputs can be overshadowed by errors in single coefficients when columns are dominated by one cell (Phibbs and

Holsman,1982).

2. Greater attention should be given to:-

   (a) Sectors showing larger multipliers particularly if their columns are relatively dominated by a small number of cells (West and Jensen,1977)

   (b) larger coefficients (Jensen and West,1980)

3. Greater attention should be given to those cells where the analyst thinks he can make the greatest absolute improvement, after adjusting for the importance of large row totals and large diagonal elements (Hamilton,1979).

4. In impact analysis, errors in the direct coefficients of sectors for which multipliers are not calculated, are relatively unimportant in influencing multiplier error (Phibbs and Holsman, 1982).

Whilstthese prescriptions are useful for the input-output analyst, they suffer from a number of problems. Firstly, they are essentially broad generalisations and extremely difficult to operationalize. Hamilton's (1979) conclusions, for example, highlight this problem. Secondly, since in most cases the simulation experiments were developed using actual input-output tables of specific regions, it is difficult to specify the extent to which the results of these experiments are region-specific, rather than generalisations equally applicable to all regions.

THE MATHEMATICAL RELATIONSHIP BETWEEN MULTIPLIER AND DIRECT COEFFICIENT ERROR

Fortunately for the input-output analyst, it is no longer necessary to rely on the results of simulation studies to evaluate methods for generating input-output multipliers. In a path-breaking paper West (1979) was able to make the simulation studies obsolete by specifying, in mathematical terms, the relationship between multiplier error and direct coefficient error. It is instructive to trace the outline of West's analysis.[7] He begins by assuming the direct coefficients error matrix P, is equal to $[a_{ij}.p_{ij}]$ - that is he accepts the proportional error hypothesis.[8] The input-output multipliers are calculated from the Leontief inverse, $B = (I-A)^{-1}$. We therefore need to know how P affects B. The new direct coefficients matrix is (A+P), and the new multipliers are derived from the inverse $(I-A-P)^{-1}$. We want to find how $(I-A-P)^{-1}$ is related to $(I-A)^{-1}$.

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7. This outline is taken directly from West (1979). It should be noted that a subsequent version of the proof (West 1981) uses different notation.

8. He contends the analysis is also possible using an absolute error hypothesis, but he considers the proportional error hypothesis to be more plausible, primarily on the basis that he considers large coefficients are more likely to contain large errors.

Now let

$$(I-A-P) = (I-A)(I-Z) \qquad 2.6$$

$$= (I-A)-(I-A)Z$$

i.e. $$P = (I-A)Z \qquad 2.7$$

From 2.6 $$(I-A-P)^{-1} = (I-Z)^{-1}(I-A)^{-1}$$

$$= (I+Z+Z^2+Z^3+\ldots)(I-A)^{-1}$$

$$= (I-A)^{-1}+Z(I-A)^{-1}+Z^2(I-A)^{-1}+\ldots$$

$$= B+ZB+Z^2B+\ldots. \qquad 2.8$$

But from 2.7 $$Z = (I-A)^{-1}P$$

$$= BP$$

Therefore 2.8 becomes

$$(I-A-P)^{-1} = B+BPB+(BP)^2B+\ldots$$

$$= B+E1+E2+\ldots$$

$$= B+E \qquad 2.9$$

where $E = E1+E2+\ldots$ is the absolute change in the Leontief inverse, B, in response to proportional changes p_{ij} in the direct coefficients a_{ij}.

Consider first the 'error' matrix E1. The $(i,j)^{th}$ element of E1 is:-

$$[e1_{ij}] = [\sum_l\sum_k b_{ik}a_{kl}p_{kl}b_{lj}] \qquad 2.10$$

where b_{ij} denotes the $(i,j)^{th}$ element of B, and the error in the

j^{th} output multiplier is

$$\varepsilon l(om_j) = \sum_l \sum_k om_k a_{kl} p_{kl} b_{lj} \qquad 2.11$$

where om_k denotes the original k^{th} output multiplier.

The absolute multiplier change in 2.10 and 2.11 does not take into account the magnitude of the multiplier, and so the proportional multiplier change is probably a more appropriate criterion, particularly as comparisons across multipliers and tables may be desired. The proportional change in the j^{th} output multiplier is therefore:-

$$\varepsilon l(om_j)/om_j = \sum_l \sum_k om_k a_{kl} p_{kl} b_{lj}/om_j \qquad 2.12$$

Equation 2.12 is in fact the summation of a series of n^2 terms, where n is the number of intermediate sectors. For each direct coefficient a_{kl} (k,l=1 .....n), there is a corresponding element in the series of 2.12, the total sumation of which gives the total proportional j^{th} output multiplier change. The elements in 2.12 can be arranged in matrix format so that each element in the matrix gives the proportional change in the k^{th} multiplier, in response to a change in the corresponding element of A. The $(i,j)^{th}$ element of this matrix wll then be:-

$$el^k_{ij} = [om_i a_{ij} p_{ij} b_{jk}/om_k] \quad .... \quad 2.13$$

A similar analysis can be undertaken for the $\bar{E}2$ and $\bar{E}3$ matrices, but the series $\bar{E}1 + \bar{E}2$ .... converges fairly rapidly, since each element of $\bar{E}1$ involves a product p/n, $\bar{E}2$ by p^2/n, $\bar{E}3$ by p^3/n etc. Hence it is possible to explain using equation 2.13, the results of the simulation experiments described above. This is obviously an important step since it allows a theoretical framework to be constructed, which connects these previously unrelated pieces of research. A detailed description of how Equation 2.13 can explain the simulation results is contained in Appendix II.

EVALUATING SEMI-SURVEY APPROACHES

The theoretical framework provided by West (1979) is a considerable asset in evaluating the various semi-survey approaches developed over the last ten years in response to the data problems of input-output analysis. Previously these approaches were judged by comparing semi-survey tables with survey-based tables for the same region. Whilst this is an important criterion for evaluation, it is now possible to complement this procedure by an evaluation of the theoretical merit of the approach. This multidimensional evaluation approach will be adopted in this section.

Su's Survey of Imports Technique.

Su (1970) proposed a technique emphasising the direct estimation of imports. He began with the assumption that whereas processes are invariant between regions in terms of their input structure, the regional coefficients differ from their national equivalents to the extent that some inputs will be imported from other regions. Thus:-

$$a_{ij} = r_{ij} + m_{ij} \qquad 2.15$$

where: a_{ij} = national technical coefficient

r_{ij} = regional trade coefficient

m_{ij} = regional input of i per unit output of vector j

Thenif p_{ij} represents the proportion of inputs from sector i imported into the region per unit of sector j, Su calculated that

$$m_{ij} = a_{ij}p_{ij}$$

and therefore:

$$r_{ij} = a_{ij} - m_{ij}$$

Su proposed that a survey of firms within the region should be undertaken to estimate the p_{ij}'s.

A study by Schaffer (1970) investigated the extent to which

Su's proposed method could be considered to produce results superior to those produced by non-survey methods. He concluded, after comparing a number of generated tables with a survey-based table for the State of Washington (Bourque *et al*, 1967) that Su's technique did not significantly improve upon the purely non-survey techniques.

Regardless of the accuracy of the technique, Su's approach seems to offer little in the way of cost advantages over traditional survey-based input-output studies. Su argues that a survey conducted on *proportion* of required inputs for each sector imported from other regions, is much easier to conduct than one on the *amounts* of required inputs produced locally. Nevertheless, such a survey would only be marginally cheaper to conduct than the traditional survey.

The GRIT Technique

The GRIT procedure, developed by economists from the University of Queensland (Jensen *et al*, 1979), is the most widely used technique for generating regional input-output tables in Australia. Since its development in 1977, approximately 50 GRIT tables have been produced for the regions in Australia, and the GRIT technique has been widely reported (See Jensen, 1980b, 1981). The procedure is best examined by evaluating two separate generations of techniques, the GRIT I technique (Jensen *et al*, 1979) and its successor, the GRIT II approach (West *et al*, 1979a).

The GRIT I methodology is summarised in Table 2.4. Essentially, the technique involves generating a prototype input-output table for a region using a mechanical simple location quotient process, and then inserting superior data into this table, in order to improve its accuracy. Although Jensen et al (1979) comment that the multipliers derived from GRIT were consistent with those derived from survey-based tables in Queensland, no attempts have been made to formally compare the multipliers from a GRIT I table and those from a survey-based table. Therefore, it is impossible to make any definitive statements about the accuracy of GRIT I. Nevertheless, despite the absence of detailed empirical data, it is possible to make some theoretical comments on the likely accuracy of GRIT I.

It is evident from the findings presented in Section 2.3, that since the draft GRIT I tables are based on the simple location quotient, they are likely to contain a large error component. The authors of GRIT would not dispute this point, and indeed, consider the insertion of superior data to be a crucial part of the technique.

Obviously, if enough superior data is inserted into the draft tables, they would become equivalent to the "true" tables and hence the GRIT technique would achieve partitive accuracy. This situation is not operationally feasible, given the resource constraints of attaining data. Instead, the GRIT tables are constructed with a view to what Jensen (1980a,142) calls holistic accuracy, which relies:-

TABLE 2.4 THE GRIT METHODOLOGICAL SEQUENCE

PHASE I ADJUSTMENTS TO NATIONAL TABLE

1 Start with national input-output table. (109-sectors, direct allocation of imports, basic values, net of intrasectoral transactions)

2 Adjustment of national table for price levels and updating.

3 Adjustment for international trade.

PHASE II ADJUSTMENT FOR REGIONAL IMPORTS

(Steps 4-15 apply to each region for which input-output tables are required.)

4 Calculation of non-competitive imports.

5 Calculation of competitive imports.

PHASE III DEFINITION OF REGIONAL SECTORS

6 Insertion of disaggregated superior data.

7 Aggregation of sectors.

8 Insertion of aggregated superior data.

PHASE IV DERIVATION OF PROTOTYPE TRANSACTIONS TABLES

9 Derivation of initial transactions tables.

10 Manual or iterative adjustments to tables to derive prototype tables.

11 Aggregation if uniform tables are required.

12 Derivation of inverse and multipliers for prototype tables.

PHASE V DERIVATION OF FINAL TRANSACTIONS TABLES

13 Final superior data insertions and other adjustments.

14 Derivation of final transactions tables.

15 Derivation of inverses and multipliers for final tables.

Source - Jensen (1981), 11A

> "not on accuracy in each cell of the table, but on the accuracy with which the table represents the main features of the economy in a descriptive sense and preserves the importance of these features in an analytical sense"

The question remains however, whether the superior data gathered in applications of the GRIT I technique, is sufficient to achieve the goal of holistic accuracy. Jensen (1981;11) states that superior data were:-

> "actively sought for the larger and more significant coefficients in the matrix".

Two interrelated issues need to be examined, therefore, in relation to the quality of the superior data inserted in the GRIT technique. Firstly, is the technique of actively seeking out superior data for the larger and more significant coefficients operationally valid, and secondly, is the amount of superior data available sufficientfor the GRIT tables to approach holistic accuracy.

In relation to the first issue, the discussion in Section 2.5 - particularly the work by Hamilton (1979) - emphasized that the larger coefficients are the most significant in determining multipier error, only if the proportional error theory is correct. Hence GRIT I's emphasis on large coefficients is only valid if the proportional error theory holds, and thus an evaluation of GRIT I has to include a test of the proportional error hypothesis.

This test was undertaken by comparing two survey-based tables with their non-survey equivalents. Firstly, data generated in the Phibbs and Holsman (1982) study of the Hunter region was re-examined. The draft regional table used in this study was derived using techniques identical to the GRIT methodology. Therefore a test of the proportional error hypothesis could be made by comparing the error between the draft table and the survey-based table for the Hunter (Garlick, 1979), with the size of the coefficients of the draft table. If the hypothesis is correct, then the larger errors should be associated with the larger coefficients of the draft table.

The test was undertaken using correlation analysis. The difference between the Phibbs and Holsman (1982) coefficients for the draft Hunter table and the coefficients of the survey-based table were calculated and correlated with the coefficients of the draft Hunter table. The resultant product-moment correlation was 0.64, statistically significant at the 0.1 percent level. However, since the GRIT technique only uses size as a ranking guide, it seemed more appropriate to use a ranking test, and hence Spearman's rank correlation coefficient was selected. The resultant coefficient of 0.77 indicated that a significant relationship existed at the 0.01 percent level. Table 2.5 lists the ranks of the draft table coefficients for the first forty absolute error ranks. For example, the coefficient with the

TABLE 2.5 COMPARING RANK-SIZE OF THE DIRECT COEFFICIENTS OF THE DRAFT HUNTER TABLE WITH ABSOLUTE ERROR RANK-SIZE.

Rank-size of the absolute errors. (the largest absolute error has a rank of 1)	Draft Hunter table. Rank-size of the coefficients (the largest coefficient in the table has a rank of 1).
1	299
2	2
3	69
4	1
5	5
6	19
7	4
8	6
9	9
10	24
11	7
12	81
13	135
14	42
15	11
16	15
17	131
18	13
19	174
20	12
21	10
22	174
23	147
24	52
25	19
26	31
27	247
28	21
29	30
30	36
31	121
32	17
33	33
34	25
35	38
36	35
37	28
38	22
39	18
40	45

Source: Compiled by author.

largest absolute error is ranked as the 299th largest draft coefficient rank. This table confirms that, although there are large discrepancies in some cases, in general large absolute error ranks are associated with the largest elements of the draft table.

The proportional error hypothesis was also tested using data generated by Morrison and Smith's (1974) simulation tests for Peterborough. Although they did not use the GRIT technique *per se*, the similarity of the technique used to generate the draft GRIT input-output table with the simple location quotient approach used in their study, is sufficient justification for using the Morrison and Smith data in a test of the proportional error hypothesis.

The magnitude of the coefficient error between the Peterborough survey table and a simple location quotient based non-survey table was calculated, and correlated with the coefficients of the non-survey table. The simple correlation coefficient was calculated to be 0.87, as was the rank correlation coefficient (both significant at the 0.01 percent level).

The results of these empirical tests indicate that the proportional error hypothesis is in general terms correct. Nevertheless, the limited empirical evidence does not provide a basis for complete acceptance of the proportional error hypothesis. However, an examination of the mechanism of the quotient approach provides further support for the proportional error theory.

Section 2.5 described how apparent cross-hauling is a major problem of the location quotient technique, and indeed the research of Cartwright et al (1981) suggests that it is the major source of error in quotient-based tables. Since this positive error in the location quotient is applied uniformly across the rows of the national table, it is clear that there is an in-built tendency in the quotient approach for the larger coefficients in each row to contain larger absolute errors. This explanation lends further support to the proportional error hypothesis.

The support for the proportional error hypothesis contained in the above analysis suggests that the approach of GRIT I in concentrating on larger coefficients is substantially correct, although in some cases it could lead to a misallocation of resources (see for example absolute error ranks 1,13,17,19,22 and 33 in Table 2.5).

Turning now to the question of the quality of superior data, it is extremely difficult to make quantitative comments on this issue. Nevertheless, it is worthwhile examining the superior data used in the main application of the GRIT I procedure (Jensen et al, 1979). In this study - which generated regional input-output tables for the State of Queensland - the only survey-based information gathered was for one industry in one region. Hence, the reliability of the GRIT tables depends on the quality of the remaining sources of superior data. A.B.S. data were available for the household row and column of the direct coefficients table, but not for the remainder of the direct coefficients table. Thus, changes to the body of the draft direct coefficients table were mainly undertaken on the basis of other survey-based input-output tables, including three Queensland regional tables, and information from industry experts. Whether this information was sufficient to enable the final Queensland tables to obtain the goal of holistic accuracy is impossible to say. Nevertheless, the presence of a number of detailed survey-based tables for Queensland regions, that surveyed the main industries operating in non-metropolitan Queensland, would have made the attainment of this goal markedly easier.

In conclusion, one would have to return an open verdict on GRIT I. Given the likely large distance of draft GRIT tables from true values, the techniques level of accuracy is intimately linked with the amount of superior data that can be inserted into the draft table. Since, in the Australian context, the amount of official published data available for this task is limited, alternative sources are required. These sources fall into three categories, namely:-

i) Borrowing values from other survey tables

ii) Information from industry experts

iii) Survey-based information

In cases where survey-based tables of similar regions are not available, and/or the complexity of the region or simple non-availability considerations means that appropriate expert advice is hard to obtain, then it would seem plausible to suggest that the attainment of the goal of holistic accuracy would require a considerable amount of survey data.

GRIT II contained several improvements to GRIT I focussing on changes to the location quotient technique and a ranking procedure for selecting coefficients that required superior data. Three adjustments were made to the simple location quotient technique. Firstly, national employment figures were adjusted for industries with a substantial import or export component. For example, where industry i's national production levels included a significant export component, then national employment was adjusted downward to reflect national employment in the production of industry i for domestic use. Similar adjustments were undertaken for industries with substantial import components. Secondly, a modification was incorporated in the quotient formula, to account for labour productivity differences between corresponding regional and national industries and between the region and the nation. The measure of productivity utilised was labour-output ratios. Thirdly, differences in demand and consumption patterns throughout the nation were taken into account in deriving, where possible, estimates of personal consumption. The last two modifications are especially useful in regions that differ markedly from the national average in terms of productivity and consumption levels.

These modifications to the location quotient seem logical and one can only agree with West et al when they state (1979a;40):-

> "It appears that the above modified LQ gives a more accurate measure of regional trade coefficients in regions which are relatively more distant from the national 'average'"

In addition to these quotient changes, the major change that GRIT II introduced was a technique that allowed coefficients to be ranked in terms of their relative importance. This technique, based on the work of West (1979), demonstrated the mathematical connection between each coefficient of an input-output table and each type of multiplier. Jensen summarises as follows (1981; 20):-

> "West's procedure allows the listing of coefficients in any table according to the magnitude of coefficient effect on average output, income and employment multipliers. .... This breakthrough paved the way for a new approach to the selection of both superior data and the use of professional exoertise in preparation of final versions of GRIT II tables. It also opened the possibility for an accuracy maximising

> approach to input-output tables in terms of securing marginal adjustments to preliminary versions of a table, by allowing the development of cost effective allocation of resources among the more "significant" coefficients for the purpose of the table."

Whilst it was acknowledged in Section 2.5 that West's technique is a major advance, it is considered that the application of the technique in the GRIT II procedure fails to acknowledge the limitations of the technique. The construction of a listing, as described above, depends on a prior assumption about the type of error that is contained in the draft table. That is, the correctness of the listing is inextricably linked with the validity of the error hypothesis. In the case of the application of West's formulae to the GRIT II approach, it is assumed that the error between the draft table and the "true" input-output table is proportional in nature. Hence, for the ranking of coefficients to be completely accurate, the proportional error hypothesis must also be correct. However, the discussion concerning GRIT I demonstrated that in some cases there was marked deviation from the proportional error hypothesis, and hence it seems reasonable to suggest that there will be some errors in the ranking of coefficients using West's technique. In order to explore the magnitude of these errors, the following analysis was performed:-

i) Using the non-survey input-output table for the Hunter region developed by Phibbs and Holsman (1982) and the equivalent survey table for the region, an (E1 + E2 + E3) matrix was generated using West's formulae. This matrix describes the impact of the error - the difference between the non-survey and survey values - in each coefficient, on the average output multiplier error. A ranking of the elements in this matrix ranks the coefficients in the non-survey table according to their impact on average output multiplier error. The ranking was based on the absolute value of elements in the (E1 + E2 + E3) matrix.

ii) Again using the non-survey table, West's technique was appliedto generate the (E1 + E2 + E3) matrix. However, in this case, instead of using the absolute errors between the non-survey and survey estimates for each coefficient, a constant proportional error of 1.0 (100 percent) was assumed. This procedure is identical to the procedure used by Grit II, to rank draft coefficients in terms of their impact on multiplier values.

iii) A Spearman rank correlation coefficient was calculated for the two matrices, and the first twenty five absolute error ranks compared with their proportional error counterparts. A high correlation coefficient would indicate that the coefficients isolated by the Grit II procedure as having the most impact on multiplier values correspond with those that are empirically measured as having the greatest impact on multiplier values.

The resultant Spearman correlation coefficient of 0.71 (significant at the 0.01 level) indicated that whilst a relationship existed between the size of the elements in the two matrices, there was substantial discrepancies between the rankings in the two matrices. This point is reinforced in Table 2.6. The table demonstrates that while the proportional error assumptions generates a ranking list that has some relationship with actual rankings, the two ranking lists display major differences (for example, absolute rankings 1,4,8). These results indicate that whilst West's ranking technique is an extremely useful guide in indicating the most significant coefficients, it does not produce a foolproof ranking of coefficients.

It might be argued that these findings may have been more sympathetic towards West's technique if the full GRIT II procedure had been used to generate the Hunter non-survey table. (The non-survey table was generated using a GRIT I approach, with the exception that national employment totals were adjusted for imports and exports). However, since the Hunter region is extremely close to the national average in terms of productivity and consumption levels, it seems unlikely that the non-survey table would have been significantly altered.

In conclusion, it would seem that GRIT II is likely to be more accurate than GRIT I in regions that are markedly different from the the national average, because of improvements to the location quotient formula. However, in relation to the overall accuracy of the technique, the same general points discussed in relation to GRIT I apply. The accuracy of the technique will be proportional to the amount of superior data that can be included.

TABLE 2.6. COMPARING THE RANK-SIZE OF ELEMENTS OF THE E1+E2+E3 MATRIX BASED ON ACTUAL ERROR, WITH ELEMENTS OF THE E1+E2+E3 MATRIX BASED ON PROPORTIONAL ERROR.

Rank-Size:Actual Error	Rank-Size:Proportional Error
1	308
2	1
3	2
4	107
5	4
6	29
7	5
8	308
9	82
10	94
11	6
12	42
13	3
14	7
15	21
16	179
17	175
18	152
19	162
20	25
21	8
22	63
23	18
24	23
25	22

Source: Compiled by author.

Since little published data is available in Australia on the intermediate coefficients of the input-output table, superior data for these coefficients has to be obtained from either survey data or from local experts. The applications of the GRIT II technique to date (see for example West _et al_, 1979a, 1979b) have placed a great deal of emphasis on the latter and in a sense the accuracy of the tables is closely related to the quality of this 'expert' advice. Jensen summarises this position as follows (1981; 20):-

> "The preparation of GRIT tables was seen, not within a consultant client context, but as a co-operative professional exercise between the GRIT team and economists in the client government"

Jensen admits that the quality of this expert advice varies from region to region. Moreover, he considers that in more diversified economies that:-

> "the general assessment of the relative assessment of 'important' linkages is a much more complex operation" (1981; 22)

The author's own experience with public sector economists in New South Wales suggests, that while they would be aware of the significant linkages in various regional economies in a general sense, they would be unable, in most cases, toquantify these linkages for insertion as superior data in an input-output table.

In summary, whilst the GRIT II technique is likely to be accurate in simpler economic regions where the major linkages are easier to quantify, it would seem that in order to achieve comparable accuracy in more complex regions, GRIT II, like its predecessor, would require a sizeable survey component. A major difference of GRIT II over its predecessor is that it uses West's ranking algorithm to help target the coefficients needed to be collected in the survey. However, the analysis in this section has shown that the algorithm will only produce completely accurate results if the proportional error assumption holds true for all coefficients. This is clearly not the case, and hence the coefficient rankings produced by West's technique may be subject to error.

The RAS Technique

The RAS technique, first developed by Stone (1961), is a constrained matrix procedure, which uses an algorithm to estimate a solution matrix, given row and column totals and an initial estimate matrix.

In its regional applications, the RAS technique takes an initial estimates matrix A - usually the national input-output matrix - and derives a regional input-output matrix A^*. The elements of A^* must be consistent with a pair of vectors u^* and v^*, which are respectively vectors of total regional intermediate output and intermediate input, by sector. Stone argues that all of the determinants of change in input-output coefficients could be subsumed under the heading of substitution (s_j) and fabrication (r_i) effects. The underlying principle of the RAS model is that the substitution and fabrication effects operate uniformly across rows and down columns.

The RAS technique, as a method for generating input-output tables, has been evaluated in a large number of studies. The findings have ranged from an optimistic view (Morrison and Smith, 1974; Hewings, 1977; Harrigan et al, 1980) to a fairly pessimistic view that considered the technique had little merit (Czamanski and Malizia, 1969; Malizia and Bond, 1974; Miernyk, 1976).

The conclusions of a selection of these studies are listed below, in order to highlight the differences between the views:-

> "of especial significance were the results obtained by the application of the RAS procedure, which proved to be for superior to all other techniques tested. Its absolute value was in no doubt" (Morrison and Smith, 1974; 82)

> "On the present evidence it would seem that survey work would be best directed towards providing the data required by the RAS

technique" (Harrigan et al, 1980; 936)

> "Clearly it offers an alternative between complete survey-based input-output models with the attendant difficulties of data collection and assembly alluded to earlier, and the rather unsatisfactory non-survey methods which rely on census data" (Hewings, 1977; 939-40)

> "In spite of its elegance and mechanical nature, which obviates the need for judgement, the RAS method is not a satisfactory way of deriving a regional input-output table from a national counterpart" (Miernyk, 1976; 48-49)

These apparently contradictory findings may be explained by analyzing in detail the aims and measurement criterion used in each study. The studies that have reported the RAS technique in an optimistic light have usually been concerned with testing the ability of the RAS technique to generate reasonably accurate input-output multipliers (That is, they have been more concerned with holistic accuracy). Those in the pessimistic camp have usually tested the technique's ability to generate input-output coefficients (That is, they have been more concerned with partitive accurcay). The RAS technique, by ensuring that the row and column sums of the input-output table are correct, exerts a downward pressure on multiplier error even when large individual coefficient errors occur. This mechanism is described in Appendix II in the section on the findings of Burford and Katz (1977).

Since this thesis is concerned with the generation of multipliers, the inability of the RAS technique to generate accurate coefficients is not an issue. Focussing instead on the technique's ability to generate accurate regional multipliers, it is worth examining the likely advantages and disadvantages of the RAS technique.

As discussed in detail in Appendix II, the tendency for errors in direct coefficients to cancel each other out when row and column sums are fixed, means that the RAS technique has the ability to generate accurate output multipliers. Nevertheless, since the RAS technique assumes that input coefficients will change in a uniform manner along rows and columns, unless the errors between the national table and the regional table are proportional in nature, large errors may occur in income and employment multiplier.[9] Hewings and Janson (1980) attempt to overcome this problem by developing a RAS-based algorithm in

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[9]. Harrigan et al (1980) and Hewings (1977) and only tested the RAS's technique ability to generate output multipliers. If income and employment multipliers were generated the error may have been significantly greater.

which some coefficients could be fixed. With their method, superior data can be inserted into the draft table before the RAS procedure is undertaken and these coefficients remain unaltered by the algorithm. The advantage of the technique is that it is not necessary to assume that input coefficients will change in a uniform manner along rows and columns.

Another solution to the problem of large potential errors in income and employment multipliers, which could be used in conjunctionwith Hewings and Janson's (1980) algorithm, would be to ensure that the errors in the draft input-output table are largely proportional in nature. When the draft input-output table is the national input-output table, then this is not likely to be the case since the major errors between national and regional tables are the result of a national industry not being represented at the regional level. However, the analysis presented in Section 2.6 suggests that the location quotient technique generates draft regional tables that largely contain proportional errors. Thus, it would seem that a logical improvement to the RAS technique would be to generate regional tables from location quotient-based draft regional tables, rather than from national input-output tables.

Nevertheless, the question remains whether the RAS technique is cost-efficient. This issue will be addressed in the next Chapter.

2.6 SHORT-CUT MULTIPLIER METHODS

Short-cut multiplier methods involve the use of short-cut multiplier formulae in order to estimate regional input-output multipliers. The appeal of this method is that it avoids the problems associated with the compilation of a complete input-output table. The history of short-cut methods for estimating regional input-output multipliers is a fairly recent one, and provides an interesting case study in the gradual development of ideas, highlighting the process of cross-fertilisation between researchers.

Early work was undertaken by Bromley (1972) and Salcedo (1972). Their work, although useful in first suggesting the concept of deriving input-output multipliers without inventing an input-output table, suffered from a number of theoretical and practical flaws. Their work and the problems associated with it are summarised in Phibbs and Holsman (1980) (See Appendix 1).

The next major contribution to the short-cut multiplier debate was provided by Drake (1976). In Drake's model the national input-output table is used to generate regional direct coefficients. These coefficients are combined with a pre-specified mathematical formula that links direct and indirect components of the multiplier, in order to estimate the indirect effects.

Examining the model in more detail, Drake adjusts the national matrix to reflect regional conditions in two ways. First, industries not located in the local region are excluded from the matrix. Second, location quotients based on earnings data are used to estimate regional production shares in the remaining industries. National coefficients modified in the preceding manner are then assumed to be the direct requirements coefficients of a local input-output table.

The indirect component of the multiplier is estimated econometrically by specifying this component as a function of the direct component. This function was derived from a regression analysis of 17 American input-output tables.

Drake tested the model by estimating multipliers for 53 industrial sectors in six regions and then comparing these estimates with survey-based multipliers. There results of this test are summarised by Drake as follows:-

> "The ratio of estimated to survey values range from 0.63 to 1.60, with about 20 percent of the estimated values falling within ± 5 percent of the survey value and 75 percent falling within ± 25 percent" (1976; 12)

These large errors are not surprising given the method that Drake uses to estimate direct coefficients. The discussion in Section

2.3 has highlighted the inaccuracy of the location quotient technique for estimating direct coefficients, except when highly disaggregated national tables are utilized. Yet Drake uses the location quotient technique at the 2-digit SIC level, to generate coefficients which are responsible for up to 70 percent of the multiplier value and used as a basis for generating the indirect effects.[10]

Drake's model was adopted by the Bureau of Economic Analysis of the U.S. Department of Commerce, and named the Regional Industrial Multiplier System (RIMS) model. Under its new title, the model was evaluated by Latham and Montgomery (1980), who compared RIMS multipliers with survey-based estimates. They reported large errors associated with the RIMS multipliers, with a maximum error of 72 percent. These results confirm the deficiences of Drake's (1976) approach and the unsuitability of his model for deriving regional multipliers.

The RIMS model was subsequently upgraded by members of the Bureau of Economic Analysis (Cartwright _et al_, 1981) and renamed RIMS II. The major changes to the model included:-

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[10]. Drake reports this figure as a "quarter to a third of the total multiplier" (1976,15). However, his calculation includes the unity value or initial final demand change in the denominator, but _not_ the numerator.

i) an improvement to the accuracy of the quotient approach by using a 469 sector national input-output table (see Section 2.4)

ii) Calculation of indirect effects by either one of two methods. One approach was essentially an extension of the RIMS econometric approach, using a wider number of input-output studies to calibrate the econometric equation. The alternative approach involved inverting the direct coefficients matrix and estimating the multipliers in the traditional manner.

Focussing here on the econometric approach,[11] Cartwright *et al* (1981) tested their RIMS II model by comparing RIMS II multipliers with survey-based estimates. Whilst the average multiplier errors for these comparisons were small, large multiplier errors occurred in a large number of sectors. For example, in comparing RIMS II multipliers with survey-based multipliers for Texas, the mean output multiplier error was 4 percent and the mean income multiplier error was 3 percent. Nevertheless for 10 of the 133 sectors of the table, the output multiplier error was greater than 30 percent while 36 sectors experienced income multiplier errors in excess of25 percent.

These results suggest that the RIM II short-cut approach is not a

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[11]. The other approach is essentially a non-survey approach and is discussed in detail in Section 2.4.

suitable technique for generating input-output multipliers.[12]

Burford and Katz (1977) built on the earlier work of Drake. They adopted Drake's general approach of equating a power series of the A matrix with the Leontief inverse.

$$\text{i.e. } (1-A)^{-1} = 1 + A^1 + A^3 + A^4 \ldots A^N \qquad 2.18$$

Using this basic identity they prove, with the aid of simplifying assumptions, that the output multiplier for sector j (u_j) is equal to:-

$$u_j = 1 + \frac{1 \cdot w_j}{1 - w_i} \qquad 2.19$$

where

w_j = sum of the intermediate inputs for sector j

w_i = mean of the sum of intermediate inputs for all sectors

Further they contend that Type 1 income multiplier (I_j) is equal to:-

$$I_j = \frac{a_{n+1,j} + \bar{a}_{n+1} (\sum_{i=1}^{n} u_{ij} - 1)}{a_{n+1,j}} \qquad 2.20$$

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12. Moreover, it should be noted that the RIMS II methodology uses the 469 sector national table . A comparable highly disaggregated table is not available in Australia.

Burford and Katz tested their output multiplier formula by generating random samples of 50 input-output matrices with matrix dimensions and column totals fixed. They computed sectoral output multipliers for each of the generated matrices. On the basisof these experiments Burford and Katz concluded that:- (1977;29)

> "The key determinants of the values of multipliers are (1) the average value of the column totals in the interindustry coefficient matrix and (2) the specific values of the individual column totals. The distribution of coefficient values in the columns has a relatively small role in determination of specific multiplier values, though multipliers do tend to be affected by the general coefficient structure within columns."

They also tested their formula for the income multiplier by comparing multiplier estimates based on their formula with survey-based values, and concluded (1977;36) that the results:-

> "indicatethe effectiveness of the approach proposed here for estimateing multipliers, not only for output but also for income"

Their multiplier formulae were subsequently tested in a paper by Phibbs and Holsman (1981). The test involved comparing output and Type I income multipliers for seven Australian input-output tables with multipliers calculated using the Burford and Katz formulae. The results of this analysis demonstrated that while Burford-Katz output multipliers were fairly close to the 'correct' multiplier values, income multipliers derived using the Burford-Katz formula were often significantly different form the 'correct' value. For example, for 6 of the 7 regions, at least 2 sectors experienced errors greater than 10 percent, with one region having 12 sectors with errors greater than 10 percent. These errors, resulting from a breakdown of the zero covariance assumption used by Burford and Katz, suggest that:- (1981;18)

> "the utility of the Burford and Katz formulae is more limited than their proponents originally claimed"

Phibbs and Holsman (1980) in an earlier paper had also proposed a short-cut formulae for output multipliers. In that paper, instead of using the Drake approach of equating the Leontief inverse to a power series, they use the full mathematical expression for the inverse of a 4x4 matrix. They thenapply a reduction technique to simplify the expression for the output multiplier. The resultant formula highlights the importance of the intraindustry coefficient and the sum of intermediate inputs. Whilst it is demonstrated that this formula is empirically accurate for small regions, the utility of the method is limited by its inability to derive the more useful income and employment multipliers, and its failure to be empirically accurate in large regions (Katz,1983).

Burford and Katz (1981) provided a further contribution to the short-cut multiplier literature, by firstly offering an alternative mathematical proof for Equation 2.19, but more importantly, providing an intuitive explanation why the formula works. They provide empirical results from the Louisiana and Georgia input-output tables which demonstrate that the first two rounds of activity (i.e. the initial change plus the direct effects) account for an average of 87 percent of the total multiplier. Since the w_j in Equation 2.19 represents the first two rounds of the multiplier, then the 'unknowns' in the equation are the third and subsequent rounds. Burford and Katz argue that because of the relative insignificance of the third and subsequent rounds, substantial errors in their estimation will only generate small errors in the total multiplier, and hence Equation 2.19 will be accurate most of the time.

In a further paper Katz and Burford (1981) suggest a marked alteration in their approach for calculating short-cut multipliers. Of their previous methodology they say:- (1981b;40)

> "It is difficult to conceive how this approach, although useful for this purpose could be extended to develop either more complexoutput multiplier formulae or to derive income and employment multiplier formulas"

Their new method incorporates a statistical approach to the problem of computing multipliers. They begin by letting R represent the set of all possible input-output matrices that possess the same known parameters - where these parameters may be the column totals of the matrix, or the row totals. They consider that the 'true' or actual coefficient matrix is among the matrices of R, but due to lack of information it is impossible to test which one it is. Therefore, Burford and Katz adopt a statistical approach to this problem, by assuming that each matrix in R has an equal chance of being the 'true' matrix. Thus R becomes a set of random matrices, with a probability distribution on its coefficients which in turn generates a probability distribution on its output multipliers. They then derive three formulae based on different parameter information, which are means of the distribution of output multipliers.

The first formula, assumes that only column totals are known, and is indentical to Equation 2.19. The second formula assumes that both row and column totals are known, whilst the third formula assumes knowledge of column totals and the single column of coefficients for the industry whose output multipliers is sought.

The three formulae were then tested using actual input-output tables for Utah, Nebraska and West Virginia. The mean errors for all three formulae were extremely low being less than 3 percent, with the maximum error for formula one being 18.4 percent, 17 percent for formula 2 and 5 percent for formula 3.

Burford and Katz have explored an interesting concept in this paper, by generating formulae that represent the mean of a distribution of multiplier values. Nevertheless, it remains to be seen whether this approach can be used to generate accurate income and employment multipliers. These types of multipliers, by far the most useful in a policy sense, offer an additional challenge to the short-cut formulae approach, since accurate aggregate impacts (i.e. output multipliers) may be comprised of inaccurate disaggregate elements. However, because the computation of income and employment multipliers requires the use of the disaggregated elements, accurate output multiplier estimates can be associated with extremely inaccurate estimates for other multipliers. For this reason, whilst Burford and Katz's latest work is by far the most promising of the short-cut multiplier approaches, a final judgement on its utility cannot be made until it has demonstrated its ability to accurately estimate income and employment multipliers.

2.7 CONCLUSION

This Chapter consists of a wide-ranging evaluation of techniques capable of generating input-output multipliers. Firstly, it established the unsuitability of survey-based tables, largely because of cost-considerations. Secondly, it generated criteria for evaluating the accuracy of alternative technique.

These criteria were used to demonstrate the unsuitability of a large number of techniques for generating input-output multipliers. Non-survey techniques were discarded although it is important to note that these techniques may be an alternative when a highly disaggregated national matrix is available. This finding is contrary to earlier evaluations that rejected non-survey techniques out of hand. Techniques based on the reduction in the size of the input-output table were also rejected. An important point made in this section was that a vigorous test of a proposed technique should involve an actual hands-on test of the method, including the collection of necessary data, rather than merely borrowing data from the benchmark input-output table.

Short-cut formulae approaches are discarded largely because of their inability to accurately estimate income and employment multipliers. The remaining technique was the semi-survey approach. Since this approach involves some collection of survey-data a number of simulation studies were undertaken over a number of years, in order to highlight what components of an input-output table have the most impact on multiplier values. The aim of these studies was to improve the efficiency of semi-survey technique by allowing the regional scientist to focus on the collection of data that had the most impact on multiplier values. These studies were reviewed in the Chapter, but more importantly a major breakthrough by West, which provides a mathematical connection between errors in an input-output table and multiplier error, was examined.

The Chapter focussed on an evaluation of the most promising of the semi-survey methods, the GRIT techniques. It was concluded that since the draft GRIT tables are likely to be substantially different from the 'correct' tables, the accuracy of the GRIT approach is dependent on the insertion of a large amount of superior data. Since the amount of published data in Australia is limited, when data cannot be borrowed from other regions and/or the complexities of the region limit the amount of quantifiable data available from local experts, a significant survey component is necessary in order to ensure the accuracy of the final GRIT table. It was argued, that the ability of West's ranking algorithm to direct the order of data gathering is limited by the algorithm's dependence on a particular assumption about the distribution of errors in the draft table. Thus, a more cost-efficient method for the collection of survey data would enhance the utility of the GRIT method. Such a method is outlined in the next chapter.

CHAPTER THREE

MORE SEMI-SURVEY APPROACHES

3.1 INTRODUCTION

In discussing the GRIT technique in the previous chapter, problems with West's (1979) ranking procedure were identified relating to the procedure's dependence on a particular assumption about the distribution of errors in the draft input-output table. In this Chapter presents an alternative model for directing the survey component of the GRIT technique is presented. In this model the survey process is aimed at establishing for individual sectors, via a mail survey, the sum of intermediate coefficients.

3.2 THE GRITSSIC TECHNIQUE

The GRITSSIC technique is based on the importance of the sum of intermediate inputs in the the determination of multiplier values. Various short-cut techniques, particularly those of Burford and Katz (1977) and Phibbs and Holsman (1980), have highlighted the importance of the sum of intermediate inputs in affecting sectoral multiplier values. However, the evaluation in Section 2.7 has shown the utility of these techniques to be limited. Nevertheless, since these studies have demonstrated that multipliers could be generated with the sum of intermediate coefficients alone, it seems sensible to persevere with the approach but to find some way of improving the reliability of the method.

The method chosen was to combine the sum of intermediate coefficients with a rough approximation of a regional input-output table. That is, an approximation of a regional input-output table is generated by the simple location-quotient approach. This table is then adjusted so that its column sums tally with survey-based sums of intermediate inputs. The input-output multipliers are then calculated in the traditional manner.

This technique is summarised in Table 3.1. The technique is an extension of the GRIT technique, but the major thrust in superior data gathering is aimed at establishing the sum of intermediate coefficients for individual sectors, via a mail survey. It could be regarded as a "semi-RAS" technique similar to the models suggested by Bacharach(1970). An empirical trial of the GRITSSIC technique in the Hunter region suggested that the method was capable of providing reliable multiplier estimates. Table 3.2 provides details of the error between GRITSSIC multipliers and multipliers based on a full survey. The maximum difference between GRITSSIC and survey-based multipliers is

TABLE 3.1 THE MODIFIED GRITSSIC METHODOLOGICAL SEQUENCE

STAGE 1-	Adjustments to National Input-Output Table
	(a) Start with 109 sector table, with direct allocation of all imports at basic values.
	(b) Adjustment for international trade.
STAGE 2 -	Adjustments for Regional Characteristics
	(a) Calculation of non-competitive imports.
	(b) Calculation of competitive imports using the simple location quotient.
	(c) Aggregation of sectors.
STAGE 3 -	Insertion of Superior Data
	(a) Insert superior published data and other relevant data if available.
	(b) Insert survey column sums for interest sectors and adjust direct coefficient columns proportionally so that they add to these values.
	(c) Insert employment and household coefficients from the A.B.S. where possible, otherwise from the GRITSSIC survey.
STAGE 4 -	Calculation of Regional Multipliers
	(a) Invert direct coefficients matrix.
	(b) Derive multipliers.

TABLE 3.2 A COMPARISON OF GRITSSIC AND SURVEY-BASED MULTIPLIERS

TYPE OF MULTIPLIER	MEAN ABSOLUTE ERROR	MAXIMUM ERROR
Simple Output	5.89	-10.61
Total Output	6.42	-11.64
Type I Income	5.19	- 9.63
Type II Income	5.50	-10.11
Type I Employment	5.41	-12.33
Type II Employment	8.38	-14.44

Source: Summarised from Table 3, Phibbs and Holsman(1982), reproduced in Appendix 1.

under 15 percent, with the absolute mean error for all multipliers being under 7 percent. A full description of this empirical test of the method is contained in Phibbs and Holsman (1982) (see Appendix 1). However, it should be stressed that a major advantage of the testing of the technique is that it is based on an actual hands-on application of the technique in a region, involving a complete mail survey. Such a procedure is a considerable improvement on earlier research, where 'testing' a technique merely involved borrowing appropriate values from an input-output table (See, for example, the comments on RMM in Section 2.3).

The utility of the technique is linked with the validity of the proportional error hypothesis. It is considered that since the errors between draft and 'true' input-output tables appear to be largely proportional, the most cost-efficient method for inserting superior data into an input-output table is to estimate the size of this proportional error. The ratio of the draft column sum to the survey-based column sum estimates this parameter. If the error in the draft GRITSSIC table was essentially non-proportional, then inserting the correct column sums as superior data, would still leave large errors in the direct coefficients matrix, which would in turn generate large multiplier errors.

This fact provides the link between the GRIT and GRITSSIC techniques. GRITSSIC is a logical extension of the GRIT technique. Since the GRIT technique implicitly assumes proportional error it would seem plausible to suggest that a cost-efficient way of generating the final GRIT table would be to ascertain the size of the proportional error, rather than attempting to change individual cells within the input-output table.

In conclusion, the logic of the GRITSSIC technique is based on the assumption that the location quotient technique generates errors that are to a large extent proportional. Once this assumption is accepted, then the cost-efficiency of the GRITSSIC technique is obvious, since the GRITSSIC approach attempts to estimate the size of the proportional error. Such an approach is able to make large reductions in multiplier error with only one piece of data - the sum of intermediate coefficients.

3.3 EXTENSIONS TO THE GRITSSIC TECHNIQUE

REDUCING THE SURVEY COMPONENT.

In the light of the significant advances made by West (1979), discussed in Section 2.5, it is possible to suggest some extensions to the GRITSSIC technique, that would enable data gathering tasks to be reduced to an absolute minimum, when an assessment of the economic impact of a single sector activity in a small region is required. Such a problem is quite common in regional science, reflecting the community's interest in knowing the impact of the gain or loss of a major employment source in a region.

West's Equation 2.13 demonstrates that the major impacts on multiplier error include error in the direct coefficients of the sector under consideration, and the household coefficients. The remaining elements of the direct coefficients matrix have a relatively minor impact on multiplier error. In order to illustrate this point $\bar{E}1^k + \bar{E}2^k + \bar{E}3^k$ matrices, based on actual absolute error, were calculated for the 11 sectors for which GRITSSIC multipliers were calculated. The matrix for the Food, Beverages and Tobacco manufacturing sector is shown in Table 3.3. The table clearly demonstrates the marginal impact that the errors in the majority of elements in the direct coefficients have on the multiplier value for the sector. An examination of the matrices for the 11 sectors reveals that the correction of error in matrix elements that are not direct coefficients of the sectors under consideration, changes the multiplier value by a maximum of only 2.5 percent.

These findings suggest that when an impact analysis for only a single sector is required, it may be possible to derive reasonably accurate multipliers if the sum of intermediate coefficients is only obtained for one sector - the one under examination - by mail survey. In order to test this hypothesis, the following empirical test was performed:-

(i) The results of the mail survey, discussed in Phibbs and Holsman (1982), were used to insert a survey-based sums of

TABLE 3.3 IMPACT ON THE FOOD,BEVERAGES AND TOBACCO SECTOR OUTPUT MULTIPLIER (% CHANGE) OF REMOVING COEFFICIENT ERROR FROM THE GRITSSIC TABLE OF THE HUNTER REGION.

SECTOR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. RURAL	2.49	0	1.17	0	0	0	0	0	-0.02	0	0	0	0	0.02	-0.01	0	0	0
2. MINING	-0.01	0	-0.06	0	-0.03	0.01	-0.03	-0.01	0	0	0	0.11	0	0	-0.02	0	0	0
3. FOOD,BEVERAGES & TOBACCO	-0.32	0	-3.06	0	0	0	-0.08	0	0	0	0	0	0	0.09	0	0	0	0
4. TEXTILES,CLOTHING & FOOTWEAR	-0.01	0	-0.04	-0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5. BASIC METAL	0	0	0.01	0	-0.15	-0.24	0	-0.01	0	0	-0.11	0	-0.02	0.03	0	0	0	0
6. FABRICATED METAL PRODUCTS & TRANSPORT EQUIPMENT	-0.03	0	-0.16	0	0.02	-0.11	-0.02	0.01	0	0	-0.03	-0.06	-0.05	-0.02	-0.26	0	0	0
7. CHEMICALS, PETROL &COAL PRODS	0.26	0	0.28	0	0	0.01	-0.39	0	0	0	0	0	0	0.02	0.14	0	0	0
8. GLASS,CLAY & OTHER NON-METALLIC MINERAL PRODS	0.05	0	-0.49	0	-0.01	0	0	0.02	0	0	0.03	0	-0.06	0.02	0.01	0	0	0
9. WOOD,WOOD PRODS & FURNITURE	0.04	0	0.01	0	0	0	0	0	-0.03	0	0	0	-0.04	-0.01	0.01	0	0	0
10.PAPER,PAPER PRODS & PRINTING	-0.04	0	0.17	0	0	0	0	0	0	0	0.01	0	0	0.01	0	0	0	0
11.OTHER MANUFACTURING	-0.23	0	0.25	0	0	-0.03	0.01	-0.01	0	0.01	-0.12	-0.02	-0.03	-0.02	-0.16	0	0	0
12.ELECTRICITY, GAS & WATER	0.24	0	0.92	0	0	0	-0.04	-0.01	0	0	0	0	0	-0.02	0	-0.03	0	-0.01
13.BUILDING & CONSTRUCTION	-0.10	0	-0.46	0	0	0.012	-0.02	-0.01	0	0	0.08	-0.05	0.16	0.49	0.20	0.02	0	0
14.WHOLESALE & RETAIL TRADE	0.36	0	-3.55	0	-0.01	-0.06	-0.06	-0.03	-0.01	-0.05	-0.04	-0.01	-0.04	-0.12	-0.13	-0.03	0	0
15.T'PORT, STORAGE & COMMUNICATION	0.73	0.04	-3.53	0	-0.02	-0.01	-0.03	-0.05	-0.01	0.01	-0.01	-0.03	-0.02	-0.23	-0.02	-0.01	0	0
16.FINANCE & BUSINESS SERVICES	1.00	0.01	0.15	0	0	0.01	-0.01	0	0	0	0.01	0.03	0.10	-0.13	0.38	0.12	0	0.01
17.PUBLIC ADMIN. & DEFENCE	1.06	0	0.12	0	0	0.01	0	0	0	0	0	0	0	0.06	0.02	0	0	0
18.COMMUNITY SERV & ENTERTAINMENT	-0.11	0	0.05	0	0	0	0	0	0	0	0	0	0	-0.01	0.07	-0.01	0	0

Source: Compiled by author.

intermediate coefficients for one sector, sector j, into the draft GRITSSIC table. The coefficients for this sector were adjusted so that they summed to this sum of intermediate coefficients.

(ii) The coefficients for all the remaining 17 sectors were unaltered, and multipliers were calculated for sector j. These multipliers were compared with multipliers derived form the survey-based table and the GRITSSIC multipliers[1], based on the insertion of sum of intermediate coefficients for 11 sectors,. reported in Phibbs and Holsman (1982).

(iii) Another sector was selected and the coefficient of this sector were adjusted so that they tallied to the survey-based sum of intermediate coefficients. <u>All</u> the coefficients for the remaining 17 sectors (including those of the previous sector j), were those of the approximate regional table. Multipliers were calculated for this sector and compared with the multipliers mentioned in (ii).

(iv) Step (iii) was repeated until multipliers for all the 11 sectors included in the original mail survey, were generated

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[1]. Where error (%) is given by $100.(1 - M_g/M_s)$

with M_g = GRITSSIC multiplier

M_s = Survey-based multiplier

(i.e. 1 mining sector, 9 manufacturing and building and construction). In order to achieve consistency with Phibbs and Holsman's earlier work, GRITSSIC multiplier were calculated using the survey table's income and employment coefficients.

A summary of the results of this procedure appear in Table 3.4. The table shows that there are only very small differences between the multipliers based on the 11 sector survey,and thel-sector survey. Therefore, it is considered that the errors between the GRITSSIC (1 sector) multipliers and the 'true' multipliers of the survey table are within reasonable bounds. The maximum error between these two latter types of multipliers, of 12.34 percent, is between the employment multipliers for the food, beverage and tobacco sector. In comparison with the 'true' multipliers of the survey table, the absolute mean errors are close to 5 percent in all three cases. This is regarded as a highly satisfactory level of accuracy.

At this stage, it is important to stress that the above findings are based on only one regional case-study. Obviously, the accuracy of the GRITSSIC (1 sector) multipliers would be worse for regional economies which are highly interconnected, since coefficients outside of the sector under study would have a greater impact on the size of the multiplier. For this reason, it is worth assessing the degree of interconnectedness, or the strength of the intersectoral linkages, of the Hunter economy.

Using Jensen and Wests's (1980) measure of

TABLE 3.4 A COMPARISON OF GRITSSIC MULTIPLIERS BASED ON A 1 SECTOR SURVEY WITH GRITSSIC MULTIPLIERS BASED ON A 11 SECTOR SURVEY AND TRADITIONAL SURVEY BASED MULTIPLIERS

SECTOR	OUTPUT MULTIPLIERS	% ERROR A[a] (THE COMPARISON WITH SURVEY-BASED MULTIPLIERS)	% ERROR B[b] (THE COMPARISON WITH GRITSSIC 11 SECTOR MULTIPLIERS)	TYPE I INCOME MULTIPLIERS	% ERROR A	% ERROR B	TYPE I EMPLOYMENT MULTIPLIERS	% ERROR A	% ERROR B
1. MINING	1.33	-4.31	3.17	1.27	-2.04	2.46	1.42	-1.25	3.50
2. FOOD, BEVERAGES & TOBACCO	1.58	-7.22	0.44	1.96	-9.33	0.34	2.03	-12.34	-0.02
3. TEXTILES, CLOTHING & FOOTWEAR	1.09	-1.90	0.59	1.08	0.29	0.40	1.08	0.39	0.46
4. BASIC METAL	1.27	-6.93	0.63	1.28	-6.80	1.33	1.26	-5.99	0.57
5. FABRICATED METAL PRODUCTS & TRANSPORT EQUIPMENT	1.27	-7.73	1.03	1.23	-6.89	0.89	1.30	-6.57	1.24
6. CHEMICALS, PETROL &COAL PRODS	1.14	-2.80	0.12	1.44	-5.32	0.58	1.50	-3.41	0.65
7. GLASS, CLAY & OTHER NON-METALLIC MINERAL PRODS	1.22	-5.87	0.20	1.36	-5.44	0.30	1.21	-4.24	0.28
8. WOOD, WOOD PRODS & FURNITURE	1.40	4.14	-0.34	1.35	6.65	-0.32	1.35	8.57	-0.28
9. PAPER, PAPER PRODS & PRINTING	1.16	2.32	0.04	1.11	1.04	0.04	1.10	0.56	0.06
10. OTHER MANUFACTURING	1.23	-10.80	-0.22	1.20	-7.72	-0.17	1.18	-5.53	-0.14
11. BUILDING & CONSTRUCTION	1.33	-5.42	-0.30	1.26	-1.05	-0.25	1.47	-0.69	-0.35
ABSOLUTE MEAN ERRORS		5.94	0.64		5.26	0.64		4.95	0.66

(a) % error a= $(M_{g1}/M_s-1).100$

(b) % error b= $(M_{g1}/M_{g11}-1).100$

where: M_{g1} = GRITSSIC (1 sector) multiplier

M_{g11} = GRITSSIC (11 sector)multiplier

M_s = Traditional survey-based multiplier interconnectedness, namely the average regional purchases coefficient, the Hunter region's interconnectivity (.2798) is ranked fourth in a list of inter-connectedness indices compiled by Jensen from 14 Australian input-output tables. The Hunter is ranked behind a metropolitan, state and national table. It is impossible to test the accuracy of GRITSSIC (1 sector) multipliers for these more inter-connected regions, but it seems reasonable to suspect their accuracy. In these cases, it would be wise to undertake further surveys in those sectors that are likely to be most affected by a change in the level of economic activity of the sector under study. These sectors could be ascertained by an investigation of the $\bar{E}1^k + \bar{E}2^k + \bar{E}3^k$ matrix for the region, where k represents the sector under consideration. GRITSSIC surveys should be undertaken for any sectors whose coefficients have a significant impact on the multiplier value for sector k.

DISAGGREGATING GRITSSIC MULTIPLIERS

It is possible, and some would argue necessary, to disaggregate traditional input-output multipliers, in order to isolate the sectoral impacts of a particular economic event. Jensen (1980b; 25) summarises the argument in favour of this approach with particular clarity:-

> "the ordinary output multiplier represents
> the sum total of interactions over all

> productive sectors in the economy, and is often quoted only in this aggregate form. It, in fact, consists of n multipliers - where n is the number of sectors in the table - each of which provides 'disaggregated' output effects by sector; this interesting and useful information is frequently ignored in the presentation of all types of input-output multipliers"

This disaggregated approach has been applied in a number of studies in Australia (see for example Phibbs (1981), Iron Triangle Study Group (1982)). This being thecase, an added advantage of a methodology for calculating multipliers would be the ability to predict reasonably accurately disaggregated multipliers. The GRITSSIC methodology's ability to estimate disaggregated multipliers is not tested in Phibbs and Holsman's research, so in order to evaluate the method's robustness in this area , Spearman rank correlation tests were undertaken for individual sectors of the GRITSSIC and survey-based open inverse tables. The results of this analysis are shown in Table 3.5. Also shown in the table, are the sum of the differences in rank between the four largest survey-based values and the corresponding GRITSSIC values. A zero value for this parameter represents a perfect correspondence in ranks.

The table clearly demonstrates that the simple GRITSSIC formulation, as reported in Phibbs and Holsman (1982), generates

TABLE 3.5 TESTING THE SIMILARITY OF THE DISAGGREGATED COMPONENTS OF GRITSSIC AND SURVEY-BASED MULTIPLIERS.

Sector	Spearman Correlation of the 4 largest values: Simple GRITSSIC	Direct Coeffs only	Dir coeffs & simple GRITSSIC	Sum of Rank Differences: Simple GRITSSIC	Direct Coeffs Only	Dir coeffs & simple GRITSSIC
2. MINING	.66	.96	.97	6	3	3
3. FOOD, BEVERAGES & TOBACCO	.80	.84	.84	3	0	0
4. TEXTILES, CLOTHING & FOOTWEAR	.87	.94	.98	3	1	1
5. BASIC METAL	.86	.95	.96	3	2	0
6. FABRICATED METAL PRODUCTS & TRANSPORT EQUIPMENT	.24	.92	.96	5	8	6
7. CHEMICALS, PETROL &COAL PRODS	.61	.93	.96	16	2	0
8. GLASS, CLAY & OTHER NON-METALLIC MINERAL PRODS	.80	.93	.91	4	2	0
9. WOOD & WOOD PRODS	.63	.86	.94	8	0	0
10. PAPER, PAPER PRODS & PRINTING	.76	.95	.98	4	2	1
11. OTHER MANUFACTURING	.72	.96	.99	14	0	0
13. BUILDING & CONSTRUCTION	.87	.97	.99	6	2	0
	$\bar{x}$ = .76	.93	.95	Σ = 72	22	11

large discrepancies with the survey-based disaggregated multiplier components. The mean rank correlation coefficient is only 0.76, and large ranking differences are common. These results strongly suggest that the GRITSSIC technique should not be used as a basis for generating disaggregated components of the multipliers.

The obvious problem then is to decide how to upgrade the GRITSSIC technique so as to generate reasonably accurate disaggregate components. West's work, and previous simulation studies, suggest that the most cost-efficient solution to this problem would be to obtain estimates of the direct coefficients of the sector for which the multiplier was being calculated. In order to test this approach, survey-based direct coefficients were inserted into the draft GRITSSIC table before it was inverted. One of two procedures was then adopted. For the first procedure, the resultant table was then inverted and the disaggregated components of the multipliers compared with the survey-based values. The results of this approach are reported in columns two and five of Table 3.5. For the second procedure, the sum of intermediate inputs were inserted into the remaining ten GRITSSIC sectors, and the direct coefficients of the draft table adjusted to equal this sum. This approach is reported in columns three and six of Table 3.5. The results in Table 3.5 demonstrate that the inclusion of the direct coefficients dramatically improves the accuracy of the disaggregated multipliercomponents. Not surprisingly, the second procedure produces the most accurate results, even though there is still some differences in ranking for the largest multiplier components.

The results suggest that if disaggregated multiplier components are required, as a minimum the direct coefficients of the sector for which the multiplier is being calculated need to be estimated. In most cases, the sum of intermediate inputs should also be estimated for other sectors in the table[2]. The exception to this rule may be for small, unconnected regions where the first and second round effects comprise a large proportion of the total multiplier effects. In the Hunter region, the first and second round effects comprise an average 91 percent of the output multiplier value for the 11 GRITSSIC sectors. In smaller regions, where this percentage is likely to be larger, calculating the sum of intermediate inputs for other sectors may not be necessary.

3.4 THE RAS TECHNIQUE

The RAS technique was examined in Chapter 2. However, the question of the cost-efficiency of the technique was postponed, in order to allow some comparisons to be made between the RAS technique and GRITSSIC.

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2. Selection of these sectors could be aided by the compilation of an $E_1^k+E_2^k+E_3^k$ matrix.

The limited available evidence suggests that the decrease in error may not be worth the increased data collection required by the RAS technique. (RAS requires the sum of intermediate outputs as well as the sum of intermediate inputs). The largest reported multiplier error between RAS and survey-based Type I output and income multipliers for the Peterborough region was 15.9 percent (Morrison and Smith, 1974; 115-117). The equivalent GRITSSIC figure for the Hunter region of 9.6 percent would suggest that the decreases in multiplier error as a result of the extra data in the RAS technique are likely to be small. Moreover, it should be remembered that the GRITSSIC column sums were estimated by mail survey, whereas the Peterborough values were merely read off the survey-based input-output table. Furthermore, the additional data requirements of the RAS approach might reduce the response rate of the mail survey, thereby reducing the reliability of the survey-based information.

In conclusion, whilst the RAS technique has the demonstrated ability (see Section 2.6) to generate reasonably accurate input-output tables, the ability of the GRITSSIC technique to perform satisfactorily using half the survey requirements of the RAS procedure, suggests that in most cases the GRITSSIC technique would be a more cost-efficient method for deriving regional input-output multipliers. Nevertheless, the RAS technique may be appropriate in certain circumstances depending on the aims and resources of a particular research project.

3.5 CONCLUSION

The methodological review of this, and the previous, chapter strongly suggests that no single method for generating input-output multipliers can be recommended for all situations. The review has revealed that the a GRIT-type model, where the estimation of the sum of intermediate coefficients is a major element of the survey effort, seems the most suitable alternative. However, the actual specifications of this model vary markedly, depending on the amount of data collected through survey methods. The analysis in this chapter suggests that the amount of data that needs to be collected by survey depends on the following factors;

(1) The amount of available published data;

(2) The type of region being examined;

(3) The number and type of industries being analysed.

For example, in the case of tables in simple rural regions, where an impact analysis is being undertaken for only one sector that has very weak linkages into the region and whose activities are similar to those already represented in a national input-output sector, then a 1-sector GRITSSIC procedure would be appropriate. That is, a survey of firms in the interest sector would be undertaken in order to estimate the sum of intermediate inputs of the interest sector. If the sector under examination is markedly differrent from any sector in the national table then a survey will be needed in order to estimate the sector's direct coefficients. This is necessary since the proportional errors associated with location quotient derived coefficients are unlikely to apply. If the analysis is being undertaken in a similar rural region for a sector with relatively strong linkages into the region (e.g. an agricultural processing industry), it would be necessary to obtain detailed information on the direct coefficients of the interest sector. If the same industry was being examined in a larger, more complex region, it may be necessary to obtain estimates of the sum of intermediate coefficients for a number of sectors with strong linkages to the sector under examination. When impact forecasts are required for a number of sectors, rather than a single sector, then the survey data requirements increases accordingly. West's sensitivity analysis (1979) is extremely useful in indicating the sectors for which this information should be obtained.

Thus, instead of a single optimum method, a continuum of methodologies is seen to exist, with improvements in accuracy requiring additional survey data. It is impossible to specify *a priori* the most appropriate approach for any given situation. The choice of approach is a matter of judgement for the regional analyst, whose decision will be related to a variety of factors, including the accuracy requirements of the study, the available resources and the amount of published data available in the region. The ability of the analyst to select the most appropriate method will be related to their experience in undertaking impact studies and hence one can only agree with

Miernyk's (1976,53) view that:

> "Judgemententers into the construction of any input-output table at many stages....The reasoning behind each decision can be carefully documented, so those who plan to use an input-output table will know why the decisions were made. Nevertheless, these decisions are still based on judgement"

CHAPTER 4

TESTING THE REGIONAL INPUT-OUTPUT MODEL - EMPIRICAL FINDINGS AND THEIR IMPLICATIONS

4.1 INTRODUCTION

Despite the considerable research committment to the input-output model as a major tool of regional impact analysis, to date very little research has been concerned with testing the predictive accuracy of impact forecasts based on input-output models. This is despite the fact that the model is based on a number of restrictive assumptions, which have over a number of years been the subject of considerable controversy. [1]

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[1]. These assumptions include:-

a) Each commodity group is produced by a unique producing industry.

b) There are no external economies or diseconomies possible.

c) There is a unique observable production process which does not allow for the substitution of inputs.

A comprehensive description of the assumptions is contained in Chapman (1965).

The limited testing of regional, as distinct from national, input-output models includes important work by Harvey (1974), Conway (1977), McNicoll and Rees (1982), Mandeville and Jensen (1978), McNicoll (1982) and Pullen and Proops (1983). Harvey and Conway have both examined the stability of regional input-output multipliers over time by comparing multipliers derived for identical regions over different years. Conway (1977;197), echoing the findings of Harvey, concluded that:-

> "the instability of multipliers over time appears to be a minor problem"

McNicoll and Rees (1982) reached similar conclusions in their study of intertemporal coefficient stability in small regions.

However since the testing in these three studies merely involved the comparison of tables, no insights were provided into the ability of the models to accurately measure real world situations. In other words, the testing says very little about what might be referred to as "model-to-ground" errors.

Similar comments can be made about the work of McNicoll (1982). McNicoll undertook an ex-post appraisal of a forecast he made in 1977 about the impact of oil supply bases on the Shetland economy in Scotland. The appraisal is undertaken using an impact forecast derived from a more recent survey-based input-output table for the region as the "actual" impact. Thus, the appraisal is only a "model-to-model" comparison.

Mandeville and Jensen's (1978) work, on the other hand, is explicitly concerned with model-to-ground error. It involved an investigation of the impact of an alumina refinery located in the Gladstone region, Queensland. Multiplier estimates were retrospectively applied to employment totals for the construction and operations phase of the refinery. The resultant predicted change of 2904 jobs between 1961 and 1971 was very close to the actual increase of 2999 jobs. However, the problem with their analysis was that there was no detailed examination of changes in other sectors of the economy.

For example, during the decade a major employer (an abbatoir) closed down and there was also a large increase in public sector employment. The latter could have had a major impact on the actual changes in employment between 1961 and 1971. If this was the case then the test of the accuracy of the multiplier estimates by Mandeville and Jensen (1978) would be inconclusive. A conclusive test of the accuracy of the multiplier would involve modelling all the changes in employment using the input-output table for the region rather than merely isolating the effects of one particular exogenous change (the alumina refinery).

The work of Pullen and Proops (1983) represents a more detailed attempt to assess "model-to-ground" error. They used employment multipliers from a survey-based table of the North Staffordshire regional economy (Pullen _et al_, 1981) to compare predicted and observed unemployment effects. They concluded that

(1983;199):-

> "The case study of indirect regional unemployment effects gives reassurance that the multipliers are a good assessment of regional inter-industry employment relationships"

However, their work suffers from a number of data problems. Firstly, they did not have access to employment figures by sector, and hence had to use registered unemployed figures in order to indirectly estimate sectoral employment changes. Secondly, the predicted numbers of unemployed were estimated using Type I employment multipliers. Given the demonstrated importance of consumption-induced impacts (Beyers, 1974; Stevens and Trainer, 1976) it would seem that the exclusion of these impacts would make a rigourous comparison of predicted and observed employment impacts difficult. Thirdly, they consider the impact of three major exogenous changes in the economy, but they do not make it clear whether these were the only exogenous changes experienced by the North Staffordshire economy during the study period.

The results of their comparison between the predicted and observed unemployed show large absolute differences, although there is a statistically significant correlation between the two sets of figures. Pullen and Proops postulate that these large absolute differences are the result of a higher ratio of registered unemployed to unemployed than their original assumption.

However, one would have to conclude on the basis of both the data problems and the inconclusive nature of the results, that whilst the results of Pullen and Proops (1983) are mildly encouraging, their work does not represent a rigourous empirical test of the regional input-output model.

Thus, it can be readily appreciated that regional input-output models have undergone anything but rigorous testing. Regional scientists, when questioned about this problem, discount it on the grounds that it is too difficult or simply not possible to undertake such investigations. However, it would seem a risky proposition to base forecasts on an untested model. It is true that the <u>ceterus paribus</u> assumption of impact analysis makes the comprehensive testing of impact models, as opposed to regional forecasting models, a difficult exercise. Nevertheless, the evaluation of impact forecasts for regions where exogenous sectoral changes in ouput are minimal-as in this study, offers considerable scope for informing the regional analyst about how the simple regional input-output model is performing.

In order to remedy what is considered to be a serious shortcoming in the regional input-output literature, this chapter focusses on the evaluation of impact forecasts generated using an input-output model for the Broken Hill region of New South Wales.

4.2 THE BROKEN HILL REGION

In 1981 the Broken Hill Statistical District had a population of 27404 persons compared to 29808 in 1971. The city of Broken Hill is located in the Far West region of New South Wales, a region consisting mainly of semi-desert areas of mesas and gibber plains and experiencing marked climatic extremes. (See Figure 4.1). The Broken Hill district was first established as a mining district in the 1870s following the discovery of silver-lead ore at Thackaringa in 1875. Several more silver-lead discoveries followed in the ensuing years, including the Umberumberka lode in 1881, which led to the establishment of the town of Silverton in 1883. Silverton grew from a settlement of 250 people in 1883 to around 3,000 in 1884. However, following the pegging of leases and subsequent confirmation of rich deposits of silver chloride at Broken Hill, Silverton began to decline as Broken Hill took over as the population centre for the district.

The Broken Hill lode was first pegged in 1883 by Charles Rasp, a German-born boundary rider. Rasp and his associates formed a syndicate to work the claim. Early in 1885 rich silver chlorides were discovered, and the syndicate was registered as theBroken Hill Proprietary Company Limited (B.H.P.). The success of the B.H.P. mine, and of other mines opened-up nearby, led to a rapid increase in population. By 1886 the number of inhabitants of Broken Hill had grown to over 3,000; by 1888 to 11,288; and by 1890 to almost 20,000. Initially, smelting operations were carried out in Broken Hill but were later moved to Port Pirie in South Australia in the mid 1890s largely because of the cost of transporting fuel to the Broken Hill smelters. The construction of the rail link from Adelaide to Broken Hill was completed in 1887, allowing the output of the mines to be transported by rail to South Australia. Broken Hill was not connected by rail with Sydney until 1927.

In the postwar years until 1972, the mining industry in Broken Hill was controlled by four major companies:-

a) North Broken Hill Ltd.
b) Zinc Corporation Ltd.
c) New Broken Hill Consolidated Ltd.
d) Broken Hill South Ltd.

In 1972, Broken Hill South Ltd ceased mining but its leases were subsequently reopened and are now operated by M.M.M. Co. Ltd., which is maintaining a small scale operation (currently approximately 100 employees). Zinc Corporation and New Broken Hill Consolidated are both subsidiaries of Australian Mining and Smelting Limited - itself a subsidiary of C.R.A. The two companies' Broken Hill operations are jointly managed and currently employ about 2,800 people. North Broken Hill is a listed public company that currently employs approximately 1,000 people.

TABLE 4.1 EMPLOYMENT BY INDUSTRY SECTOR - BROKEN HILL STATISTICAL DISTRICT 1981.

Sector	Number	Percentage of Total Workforce	Corresponding NSW Percentage.
1. Agriculture	94	0.9	5.8
2. Mining	4630	44.8	1.4
3. Manufacturing	363	3.5	24.4
4. Elec, Gas & Water	317	3.1	1.9
5. Construction	490	4.7	7.3
6. Wholesale & Retail	1583	15.3	18.2
7. Transport & Storage	378	3.7	5.3
8. Communication	127	1.2	2.0
9. Finance	339	3.3	7.7
10.Public Admin.	218	2.1	5.1
11.Community Services	1184	11.4	9.9
12.Entertainment	618	6.0	6.0
Total	10341		

Source: Australian Bureau of Statistics

The breakdown of employment by industry sector, shown in Table 4.1, clearly demonstrates that mining is the lifeblood of the city's economy, employing 45 percent of the total workforce. In comparison to the highly developed mining sector, other sectors of the economy are relatively underdeveloped and, in terms of employment are well below NSW averages. Manufacturing activity is concentrated on the manufacture of immediate consumption items - food, beverages, newspapers. Some manufacturing industry supports the mining sector - mostly machine, welding and boilermaking shops. Moreover, the manufacturing establishments predominantly serve local (sometimes regional) demand rather than the wider state or national markets.

4.3 THE ADVANTAGES OF SELECTING THE BROKEN HILL REGION

The advantages of selecting the Broken Hill region for testing the input-output model are as follows:-

a) It is an isolated region and hence inflows and outflows are relatively easy to measure. The nearest cities with larger populations than Broken Hill are Adelaide, Wagga Wagga and Tamworth (see Figure 4.1). This relative isolation would suggest that cross-hauling of goods is likely to be less prevalent than in more populated areas. Another feature of Broken Hill's isolation is the almost negligible amount of commuting into and out of the region. Moreover, except for a small tourist component, the largest proportion of the consumption of goods and services within the region is by local residents. This means that the A.B.S. employment-by-industry figures for the resident population can be used to identify the number of jobs by industry in the region (when there is a large amount of commuting to and from a region, journey to work statistics have to be used to generate comparable employment figures).

b) The economy of the region is dominated by one basic sector, namely mining. This means that the level of economic activity in the region is inextricably linked with the fortunes of the mining sector. This situation is an ideal scenario for the testing of a cross-sectional model, such as input-output, since changes in business confidence related to the national business cycle, that do not affect the mining sector, are unlikely to have a marked impact on employment in the region.

c) The mining sector experienced a marked decline between 1971 and 1976. Operations at the Broken Hill South mine were drastically curtailed and as a result mining employment decreased by 872 jobs during this period. The major decline in employment was experienced in 1972-1973. This suggests that an ideal test for the input-output model would be to estimate employment change in the region in the 1971-76 period and compare these estimates with Census data.

d) Lastly and most importantly, apart from the mining sector, it appears that no other sectors in the region have experienced major exogenous changes in the 1971-76 period. The one exception could be in the services sector where it is possible that exogenous increases in final demand occured as a result of increased government expenditure. (The question of changes in the service sector will be further explored in the section on empirical results). This is a considerable advantage since it means that the major assumption of impact analysis, the <u>ceterus paribus</u> assumption, holds true and as a result regional employment figures can be used to test the accuracy of impact forecasts for one sector. In more complex regions, sectoral estimates of changes in final demand would need to be generated and regional employment figures adjusted on the basis of these estimates, before any test of impact forecasts could even be considered. (This issue was addressed in Section 4.1 in the discussion of the work by Mandeville and Jensen (1978)).

The basic structure of the test described in this chapter is to derive an input-output table for the region in 1971 and use it to model the impact of the change in mining employment on the regional economy between 1971 and 1976. The predicted changes in employment can then be compared with the actual changes in employment recorded at the 1976 census, thereby verifying the predictive accuracy of the model. Some input-output analysts might argue that such a procedure introduces a bias in the testing process against the input-output model, since of the three variables output,income and employment, the latter is the one that is least reliably forecast by the input-output model.

There are, however, two important reasons why employment is chosen in this study as the main variable for the test.

Firstly, employment data are readily available at the regional level in Australia, whilst regional output data are relatively scarce. Secondly, and more significantly, employment forecasts are considered by policy makers to be the most important product of impact studies, and hence it seemed appropriate to test the most commonly used application of the input-output model.

4.4 CONSTRUCTING THE 1971 INPUT-OUTPUT TABLE

The 1971 Broken Hill input-output table was constructed using the the GRITSSIC method presented in Chapter 3. However, since in this case a sectorally disaggregated mining sector multiplier is required, the direct coefficients for the mining sector need to be inserted in the input-output table rather than merely an estimate of the sum of intermediate coefficients.

More specifically, the preliminary 12 sector table, generated using the simple location quotient and the 1974-75 national input-output table (ABS,1981), was amended in a number of ways. Firstly, survey-based direct coefficients for the mining sector were inserted into the table. These were estimated in the following way. The Zinc Corporation provided information on the value and the source of its purchases for the 1981-82 financial year. Where the source of a good (as distinct from a service) was Broken Hill, the Corporation also indicated whether the good was manufactured within the region or imported and sold through a local distributor. This task was simplified by the company's computer ordering system which provided a computer listing of all purchases made through the company's Stores Department. An advantage of this listing was that it omitted special order purchases, or once-off orders such as capital equipment, which meant the list was extremely suitable for an input-output accounting framework. The Broken Hill purchases were sectored and expressed as a proportion of total purchases. The company was then asked to specify the likely changes to these purchase coefficients between 1971 and 1981. Although this seems like a difficult task, it must be remembered that staff turnover at the Broken Hill mines is extremely low, and it was not difficult to find employees who were prepared to comment on any likely differences between the two years. Some minor adjustments were made to these coefficients, mainly as a result of changing mining technology. It must be stressed that this task of downdating the coefficients was aided by the fact that the Broken Hill purchase coefficients were extremely small, and hence changes only had to be made to a small proportion of the mine's total purchases. Downdating the entire set of technical coefficients for the mine would have been a much more onerous task.

These purchase coefficients were then converted to direct input-output coefficients with the help of A.B.S.(1973) mining statistics for 1971 and Annual Reports of the mining companies. These sources provide information on total output of the Broken Hill mines as well as the proportion of total output spent on the purchase of goods and services.

Secondly, changes were made to a number of intermediate coefficients in the table. The importance of the agricultural sector as a supplier of raw materials was downgraded, since most of the agricultural commodities processed by the local manufacturing sector are imported. Also, since the entire output of the mining sector is exported from the region, all the coefficients in the mining sector row were set to zero. In addition, to downgrade the significance of the manufacturing sector as a supplier of the construction and public administration sectors, the manufacturing input coefficients for these sectors were reduced. Finally, in order to allow for the fact that electricity for the city was generated by diesel generators and used large quantities of imported oil, the wholesaling input coefficient for the electricity sector was increased.

It was considered that after making these adjustments the table provided a reasonable representation of the Broken Hill economy in an holistic sense (Jensen,1980a). As mentioned above the particular nature of the region aided the accuracy of the table, since a major weakness of the location quotient method (cross-hauling) was likely to be less of a problem in the Broken Hill case.

Income and employment coefficients were based on a number of sources. If A.B.S. data for the region were unavailable, either coefficients from the national table or coefficients from input-output studies of similar regions were used. In particular the work of Mandeville and Powell (1976), Harvey (1974) and Jensen <u>et</u>

al (1979) was useful in this context. Employment coefficients were adjusted to 1971 using the Consumer Price Index.

Consumption coefficients were likewise derived from a number of sources. The 1974-75 household expenditure survey(A.B.S.,1977) was used to derive consumption coefficients for a variety of sectors. These were converted to local purchase coefficients and an import residual using A.B.S. employment data for the region. The resultant coefficients were modified on the basis of comparison with the above-mentioned input-output tables.

The final input-output table is shown in Table 4.2. Before using this table to generate an employment multiplier for the mining sector, it is useful to consider the utility of comparing the forecast and actual employment change in assessing the accuracy of the input-output model. In other words, it is necessary to know the extent to which differences in forecast and actual employment will be the result of confounding factors rather than deficiencies in the input-output model per se. In order to answer this question the next section examines the factors that may confound the results of the test, and attempts to assess their relative importance.

4.5 CONFOUNDING FACTORS

The confounding factors can be classified into two groups.

TABLE 4.2 BROKEN HILL INPUT-OUTPUT TABLE 1971.

SECTOR	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Agriculture	.0370	0	.0007	0	0	0	0	0	0	0	.0001	.0001	.0006
2. Mining	0	.0003	0	0	0	0	0	0	0	0	0	0	0
3. Manufacturing	.0105	.0038	.0562	.0024	.0559	.0067	.0338	.0020	.0059	.0011	.0121	.0207	0
4. Elec, Gas & Water	.0172	.0803	.0226	.2085	.0559	.0142	.0143	.0064	.0242	.0316	.0445	.0699	.0100
5. Construction	.0044	.0066	.0064	.0187	.0033	.0073	.1147	.0062	.0073	.0373	.0310	.0112	.0070
6. Wholesale & Retail	.0298	.0009	.0606	.0180	.0535	.0620	.0583	.0102	.0127	.0049	.0159	.0261	.1890
7. Transport & Storage	.0166	.0016	.0402	.0117	.0349	.0188	.0122	.0171	.0063	.0112	.0197	.0125	.0150
8. Communication	0	.0001	.0001	0	0	0	0	0	.0086	.0151	0	.0012	.0099
9. Finance	.0001	0	.0062	.0007	.0108	.0547	.0011	.0009	.0413	.0277	.0006	.0141	.0651
10. Public Admin.	.0010	.0001	.0003	0	0	0	0	0	.0002	.0001	.0001	.0002	.0021
11. Community Services	.0038	.0010	.0001	0	0	.0001	.0012	0	.0023	.0019	.0007	.0027	.0053
12. Entertainment	.0004	.0005	.0028	.0020	.0001	.0042	.0020	.0001	.0266	.0079	.0027	.0201	.0630
13. Households	.0360	.3260	.2972	.2540	.3120	.4083	.5530	.5954	.4230	.6500	.6490	.3974	0

Source: Compiled by author.

The first is related to data limitations of the input-output table shown in Table 4.2, and the employment data for the Broken Hill region. The second relates to inherent limitations of the simple input-output model, namely the model's ability to forecast employment changes using only direct employment data.

Turning firstly to the data considerations, it must be emphasised that the task of constructing an input-output table ten years in the past raises special problems. The data for the mining sector, while being of exceptional quality for representing current day transactions, has to be adjusted back to the 1971 time period. Furthermore, unlike most applications of the GRIT technique (for example, see West et al 1979a), little superior data were inserted for the remainder of the intermediate coefficients of the table. However, this would not appear to be a serious deficiency, since as West (1980) stresses, small coefficient changes have little effect on multipliers, even for highly connected regions.

In order to quantify the impact of errors in the coefficients for which superior data were not available, West's(1979) sensitivity analysis formulae were applied to the Broken Hill table. More specifically, an $(\bar{E}_1^k + \bar{E}_2^k)$ matrix was calculated for the mining sector (i.e. k=2), assuming a proportional error in the coefficients of 50 percent. This matrix specifies the impact of a 50 percent error in coefficient a_{ij} on the mining multiplier. The matrix is shown in Table 4.3.

TABLE 4.3 THE SENSITIVITY OF THE MINING EMPLOYMENT MULTIPLIER TO
A 50 PERCENT CHANGE IN THE COEFFICIENTS OF TABLE 4.2.

SECTOR	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Agriculture	0	0	0	0	0	0	0	0	0	0	0	0	.0001
2. Mining	0	.0002	0	0	0	0	0	0	0	0	0	0	0
3. Manufacturing	0	.0036	.0013	.0003	.0008	.0006	.0005	0	.0002	0	.0001	.0006	.0151
4. Elec, Gas & Water	0	.0604	.0004	.0179	.0001	.0011	.0002	0	.0007	0	.0001	.0016	.0034
5. Construction	0	.0069	.0002	.0022	.0001	.0007	.0017	0	.0003	0	.0001	.0012	.0033
6. Wholesale & Retail	0	.0013	.0021	.0029	.0012	.0087	.0012	.0001	.0007	0	.0001	.0012	.1207
7. Transport & Storage	0	.0023	.0014	.0020	.0008	.0027	.0002	.0001	.0003	0	.0001	.0006	.0098
8. Communication	0	.0001	0	0	0	0	0	0	.0004	0	0	0	.0052
9. Finance	0	0	.0001	.0001	.0002	.0051	0	0	.0015	0	0	.0004	.0279
10. Public Admin.	0	.0002	0	0	0	0	0	0	0	0	0	0	.0016
11. Community Services	0	.0020	0	0	0	0	0	0	.0002	0	0	.0017	.0047
12. Entertainment	0	.0008	.0001	.0004	0	.0007	0	0	.0016	0	0	.0010	.0473
13. Households	0	.2375	.0052	.0211	.0035	.0293	.0056	.0021	.0114	.0005	.0021	.0090	0
Column Totals:	0	.3153	.0108	.0469	.0067	.0489	.0094	.0023	.0173	.0005	.0026	.0173	.2391

Summing all the entries in the matrix reveals that if a +50 percent error occurred in each coefficient shown in Table 4.2, then the mining employment multiplier would increase by 72 percent. However, instead of presenting an aggregate error figure, it is more useful to decompose this error into its various components. The sum of column 2 of Table 4.3 is 0.3153. This means that a 50% error in each of the mining sector input coefficients of Table 4.2 (including the income coefficient) will result in a 31.53% error in the mining multiplier. The sum of the last column (household consumption) of Table 4.3 is 0.2391. Thus the impact of a 50% error in each of the household consumption coefficients of Table 4.2 results in an error of 23.91% in the employment multiplier for the mining sector. A 50% error in the coefficients of Table 4.2, for which the superior data were not gathered (i.e. column 1 and column 3 to 12), results in only a 7.22% change in the employment multiplier for the mining sector.

These results validate the strategy of ignoring the collection of superior data for the majority of coefficients in the input-output table, since they have little impact on the mining sector multiplier. They also provide reassurance in that the coefficient which has the greatest impact on the numerical value of the mining multiplier (the income coefficient for the mining sector) is based on reasonably hard data, namely A.B.S. estimates and Company balance sheets for 1971.

The second confounding data factor, is the absence of annual employment data for the region. Since employment data are only available for Census years, it is impossible to generate an employment profile which illustrates the dynamic nature of the multiplier. Some analysts may argue that the lagged nature of multiplier impacts would mean that the full multiplier impacts would not have been experienced by 1976. However, the fact that the greater part of the direct impact was experienced in 1972-73, and recent evidence that multiplier impacts feed fairly rapidly through the economy (Thompson et al,1979), suggest that the 1976 employment figures should represent a new equilibrium level for the regional economy.

The first of the confounding factors related to the inherent limitations of the input-output model that must be considered is unemployment. The simple input-output model does not consider the expenditure impacts of the unemployed since the model assumes that people who lose their jobs are completely removed from the regional economic system. In actual fact they may either remain in the region as unemployed, or may retire from the work-force. In either case they still take an active part in the regional economy, even though their expenditure levels may be considerably reduced. If a large number of people who lost their jobs in a region retired or remained in the region and received unemployment benefits a traditional input-output table of the region would overestimate the total employment impact of a fall in exogenous employment. More sophisticated input-output models overcome this problem by generating a separate consumption function for the unemployed and setting the input-output model in a demographic framework (see, for example, Batey and Madden, 1981). A full economic-demographic model of Broken Hill is beyond the scope of this thesis. Nevertheless, some general comments may be made about the potential seriousness of this problem for the Broken Hill region during the 1971-76 period.

Broken Hill residents are very aware of the city's dependence on the mining industry. Metal prices appear daily on the front page of the local newspaper and there is a general realisation that "if the mines go, then the city goes". As part of this awareness, there is a general feeling that if the mining sector falters, then people should pack their bags and leave. This attitude could be contrasted with attitudes in more diversified regions where the "something else might turn up" view is more common. In the light of this attitude, it is not surprising that people currently employed in the mining industry interviewed during August 1982 felt that the majority of miners who did not get other jobs when the Broken Hill South mine closed had left the city by 1976 in search of jobs elsewhere. The possible exception to this was the older miners in the 45-60 age category, many of whom obtained short term employment in Rural Employment Relief schemes. The harsh natural environment probably meant that few of the miners actually retired within the city, preferring instead to settle 'on the coast'.

For other workers, indirectly affected by the reduction in mining employment, the situation is less clear. However, it would appear that the employment opportunities in other regions for this group were not as good as for miners, and as a result there may have been a greater tendency for this group to remain in the region on unemployment benefits. This notion is supported by the increase in unemployment recipients between 1971 and 1976 from 205 to 683 persons . However, C.E.S. records indicate that in 1976 approximately 48 percent of those unemployed were juniors, compared to a 1971 figure of approximately 30 percent. This implies that a large proportion of the increase in unemployment was a result of the increase in unemployment amongst school-leavers rather than as a result of people loosing their jobs and remaining in Broken Hill on unemployment benefits.

The view that a significant number of people who lost their jobs between 1971 and 1976 outmigrated from the region is reinforced by net migration figures. Between 1971 and 1976, net migration was estimated to be -2850 (Broken Hill Review Committee, 1980). Clearly some of this outmigration would have been the result of normal outmigration of young, single people from the city. An indication of the size of this component can be obtained by examining net migration estimates for the previous intercensal period (1966-1971). During this period when there was a decline in the labour force of only 66 jobs, net migration was -1019. Therefore, for the 1971-76 period outmigration would appear to be in the order of 2,000 persons above the normal figure. These results support the view that a large proportion of those who lost employment in the region migrated from it. Finally, it is worth noting that the ratio of people employed to total population changed only marginally, from 0.3588 to 0.3550, between 1971 and 1976.

In summary, it is considered that because of the special nature of the Broken Hill region, the problem of people losing their jobs and remaining in the economic system is less significant there than in other regions. A considerable proportion of those who lost their jobs between 1971 and 1976, particularly miners, appear to have left the region. Nevertheless, the increase in unemployed over the period not attributable to school-leavers, would suggest that, to a small degree, the simple input-output model overestimates employment impacts.

The second confounding factor relating to the limitations of the simple input-output model is the impact of tourism on the region. If there was a large increase in tourism in the region between 1971 and 1976, then the difference between the 1971 and 1976 employment figures would not only measure the impact of the decrease in mining but would also reflect the employment impact of increased tourist expenditure, therefore confounding the test of the input-output model. Fortunately some evidence is available on this from a report on tourism in the region (Planning Workshop, 1977). This report traced visitors statistics for a number of major tourist attractions in the area in the period 1971-1976 and concluded that growth had been steady (in the order of 6 percent per annum). The report also estimated that between 1971-1976, there was a 10 percent decrease in employment attourist accommodation establishments - the major employer in the tourist sector. The report (1977;79) considers that:-

> "the competitiveness of the industry is such that the high cost of labour is requiring a reduction in the units of labour employed and thus probably a reduction in services offered".

It would seem fair to conclude that the percentage change in tourist employment between 1971-76 is likely to have been small. Given that tourist sector employment was estimated to be in the vicinity of 300 persons in 1976 (Planning Workshop,1977,84-86), the overall impact of changes in tourism related employment is likely to be small and not a serious problem in the evaluation of the input-output model for Broken Hill.

The final confounding factor relating to limitations of the simple model is concerned with its inability to assess the impact of changes in capital expenditure. This is likely to lead to errors in forecasting employment changes in the construction sector. Nevertheless, it seems that only this sector will be affected since capital expenditure in the remaining sectors would be subject to massive leakages. As a consequence, the error in the aggregate multiplier is likely to remain within reasonable bounds.

In summary, the examination of possible confounding factors reveals that these factors should not lead to markedly distorted input-output forecasts. Nevertheless, it is equally evident that a comparison of forecast with actual employment figures for the region will not indicate that the input-output model *per se* generated an x percent error. Rather,the comparison of actual and forecast employment estimates will highlight broad trends. This will be especially true when forecasts disaggregated by sector are compared with actual sectoral employment figures.

4.6 EMPIRICAL RESULTS

Table 4.2 was used to generate a Type II employment multiplier for the mining sector in the traditional manner (Richardson,1972). The resultant value of 1.55 indicates that for every mining job lost, an additional 0.55 jobs would be lost in the remainder of the economy. This suggests that a loss of 831 jobs in the mining sector would lead to the loss of a further 457 jobs in the remainder of the economy. However, between 1971 and 1976 the net loss of jobs in the non-mining sector of the economy totalled only 24 jobs. This difference would seem to indicate that the multiplier estimate is seriously in error. Some light can be shed on this problem if the multiplier is disaggregated into its sectoral components. Table 4.4 shows the forecast decrease in jobs in the non-mining sectors as a result of the loss in mining employment, predicted by the simple model.

Large discrepancies between forecast and actual changes in employment are associated with the Community Services and Public Administration sectors. Clearly there has been a substantial increase in employment in these sectors even though the remainder of the Broken Hill economy has been in decline. It would appear that this trend is not explained by local conditions, but rather

TABLE 4.4 FORECAST AND ACTUAL CHANGES IN SECTORAL EMPLOYMENT RESULTING FROM THE LOSS OF 831 MINING SECTOR JOBS,1971-76

Sector	Forecast Change	Actual Change[a]	Difference
Agriculture	0	-11	-11
Manufacturing	-23	-76	-53
Elec, Gas & Water	-63	41	104
Construction	-18	-50	-32
Wholesale & Retail	-195	-136	59
Transport & Storage	-23	15	38
Communication	-10	14	24
Finance	-32	-70	-38
Public Administration	-5	105	110
Community Services	-13	197	210
Entertainment	-77	-53	24

(a) Source: ABS Census data adjusted for underenumeration.

it is related to a national trend towards an expansion of public service employment during the time period under consideration. For example, at the national level the ratio of employment in Public Administration and Community Services to national population increased by 26 percent, from 0.0608 to 0.0764 between

1971 and 1976.

Therefore, there was an exogenous increase in employment in Public Sector employment in the period 1971-76. Assuming that the sectoral input forecasts for Public Administration and Community Services are correct then it is necessary to model the impact of an exogenous increase of 110 persons(105+5) in Public Administration and 210 persons (197+13) in Community Service employment. In order to accomplish this task, telephone surveys were undertaken for both these sectors in order to ascertain the sum of intermediate inputs for each of the sectors. The resultant values were inserted into the input-output table and the direct coefficients adjusted so as to sum to these totals. The resultant direct coefficients table was inverted and Type II employment multipliers were calculated for both sectors. The multiplier values of 1.40 and 1.29 were applied to the exogenous increases in employment specified above. Table 4.5 shows the results.

The results show that when the impact of the exogenous increase in employment in public administration and community services is considered in the analysis, the predictive performance of the input-output model is considerably improved. The aggregate error is only equal to 8 jobs. This not withstanding, it is useful to analyse the performance of the model at the sectoral level.

Table 4.6 shows the sectoral forecasts for the non-exogenous sectors as well as the actual sectoral changes in employment. The forecast changes in sectoral employment are different to those contained in Table 4.4 since the flow-on impacts of increases in the public service sector are included in this table. The figures demonstrate that at the sectoral level, the performance of the model is much less satisfactory. Furthermore, the good

TABLE 4.5 FORECAST AND ACTUAL EMPLOYMENT CHANGES IN NON-MINING SECTORS AS A RESULT OF EXOGENOUS EMPLOYMENT CHANGE.

Sector	Type II Multiplier	Exo. change in direct employment	Change in non-mining employment
Mining	1.55	-831	-457
Public Admin.	1.40	110	154
Commun. Serv.	1.29	210	271
		Total change	-32
		Actual change	-24
		Residual	- 8

performance at the aggregate level would appear to be the result of cancellation of errors at the sectoral level. The major discrepancies apparently are as follows:-

a) Manufacturing:- The major decrease in manufacturing employment was in printing and publishing, which lost 47 jobs. Further enquiries in Broken Hill revealed that this loss was mainly due to the closure of the newspaper (the Barrier Daily Truth), which closed in November 1974, resulting in a loss of 39 jobs.

TABLE 4.6 FORECAST AND ACTUAL CHANGES IN SECTORAL EMPLOYMENT-NON-EXOGENOUS SECTORS 1971-1976.

Sector	Forecast change	Actual change	Discrepancy
Agriculture	0	-11	-11
Manufacturing	-17	-76	-59
Elec,Gas & Water	-60	41	101
Construction	-12	-50	-38
Wholesale & Retail	-146	-136	10
Transport & Storage	-14	15	29
Communication	- 4	14	18
Finance	-23	-70	-47
Entertainment	-59	-53	6

b) Electricity, Gas and Water:- The large demand of the mining sector for electricity causes the input-output model to forecast a significant decrease in employment in this sector.

However, employment in the electricity, gas and water sector actually increased by 41 jobs, largely as a result of an increase of 30 jobs believed to be in electricity generation and distribution. The anomaly between forecast and actual employment in this sector is a result of two factors. Firstly, the engineering characteristics of electricity generation mean that decreases in the amount of electricity generated does not necessarily lead to a decrease in labour requirements. Generators still need to be operated and maintained. Management of the Western New South Wales Electric Power Company, the main generating company for the mining sector, reported that the decrease in consumption was not sufficient to justify any reduction in employment. Secondly, the attempts by management of this company and the other private electricity company in the city (Southern Electric) to alleviate the impact of the Broken Hill South closure resulted in a slight increase in employment.

c) Construction:- The significant decrease in construction employment (50 jobs) was not forecast by the model. This is largely because the input-output model ignores the impact of capital expenditure, such as housing construction. During the 1971-76 period building completions decreased significantly in both the dwelling and non-dwelling sector. In 1971, 132 new dwellings were completed, while in 1976 the figure was 33. The value of non-dwelling building completions, at constant 1974-75 prices, was $5.479m in 1971 but decreased to $1.259m in 1976 (D.I.D.D., 1980). This slump in the building sector resulted in a fall in construction employment that was not forecast by the input-output model.

d) Finance:- The large reduction in employment for this sector (70 jobs) was largely a result of a decrease of 52 jobs in cleaning services. Such a large drop is difficult to explain, especially since a local industry expert - a man who has been in the cleaning business in Broken Hill for 20 years - considers that no more than a few people were employed as contract cleaners in 1971. This anomaly could result from an error in the ABS data or the presence of a large number of non-resident cleaners in 1971.

4.7 IMPLICATIONS OF THE EMPIRICAL FINDINGS

The empirical results of the preceding section highlight a number of problems associated with impact forecasts based on the simple input-output model as applied in Australia over the recent past. These can be divided into three categories:

a) those due to stretching the model beyond its limitations;
b) those due to restrictive assumptions;
c) those related to modelling changes in public sector service employment.

In this section, each of these problems are discussed, and suggestions made about possible methods of overcoming them.

STRETCHING THE MODEL BEYOND ITS LIMITATIONS.

The error in the forecasts of employment change in the construction sector could be included in this category. This error results from the omission of capital expenditure considerations the simple input-output table. It might be argued that the easiest remedy for this would be to contaminate input-output accounts and include capital expenditure for the construction sector. However, besides contaminating the accounting framework of the input-output system, this is extremely difficult to do due to the large fluctuations in construction activity over time. A more reasonable solution to this problem involves making an independent assessment of the change in activity in the construction sector resulting from developments in a region, and multiplying this initial change by the construction sector multiplier. The resultant change in employment could then be added to the multiplier effect estimated in the traditional manner.

The practice of omitting capital expenditure for the construction sector is widespread in Australian impact studies. Whilst project construction expenditure is usually included, non-project expenditure, in particular expenditure on housing is usually omitted. For this reason it is considered that some Australian impact studies, especially studies of major resource projects, may have seriously underestimated construction sector impacts.

THE RESTRICTIVE ASSUMPTIONS OF THE MODEL.

The errors related to the restrictive assumptions of the model are well illustrated by the electricity and manufacturing sectors. The input-output model assumes that inputs are a linear function of outputs, but the electricity sector exhibits a "lumpy" relationship due to economies of scale. Furthermore, the model predicts that the input-output function is a continuous curve. However, in the case of the newspaper and printing sector in Broken Hill, it is evident that a large discontinuity exists. In reaction to falling demand the Barrier Truth newspaper could trim inputs to a certain extent. However, beyond this limit, the firm had no choice but to close entirely resulting in a negative error in the forecast.

In addition, the case of the electricity sector demonstrates an interesting phenomenon discussed by Brownrigg (1980,204), who argued that employment reduction in a region in response to a decrease in direct employment will be:-

> "less than the reduction indicated by a purely theoretical model. People resist redundancy; employers, unless their own survival becomes an urgent priority, may

> take the softer option of relying on natural wastage, or hoping for an economic upturn to absolve them from the responsibility of making a full adjustment to their manning levels"

In the electricity sector, this possibly more typical "non-theoretical" behaviour was evident, with employers providing additional job opportunities in an attempt to alleviate the impact of the major decrease in mining employment.

In some cases, it may be possible to make mechanical adjustments to the model in order to minimise problems with these assumptions, but the capacity for accurate adjustments are limited. This would suggest that the use of disaggregated multipliers _per se_, where the aggregate employment multiplier is disaggregated by sector, is a risky practice and likely to lead to erroneous results. Perhaps it would be wiser to merely identify those sectors in which the largest multiplier impacts will be experienced rather than specifying quantitative sectoral impacts.

FORECASTING CHANGES IN SERVICE SECTOR EMPLOYMENT.

The large errors in the forecast values of employment in the Public Administration and Community Services sectors (hereafter referred to as the Service sector) shown in Table 4.4 were mainly attributable to the initial impact forecasts not allowing for the large exogenous increase in service sector employment between 1971-1976. It might be argued that since this increase in employment did not meet the ceteris paribus assumption of impact analysis, the large errors do not reflect badly on impact forecasts generated using input-output models. However, this increase in the size of the service sector has been a prominent feature of recent Australian and international economic history.

Table 4.7 lists the service employment to population ratios for Australia and a number of other countries for the period 1974-1980. The Table shows that the service sector grew in all countries in the Seventies, although restrictive fiscal policies led to a slow-down in growth, or in some cases absolute decline, toward the end of the decade. The figures available for Australia show that contractionary policies had only a limited impact on the service sector. For example, ABS data reveal that the ratio of employment in Public Administration and Community Services to population increased by 16.1 percent between 1976 and 1981.

In addition to the problem related to the growth of the service sector, the simple input-output model suffers from another problem that affects its ability to accurately estimate service sector impacts. This problem is related to the model's dependence on the measurement of cash flows from the household sector in order to estimate employment changes. For example, most Australian impact studies have attempted to measure Community Service impacts by closing the input-output model with respect to households, and measuring the impact of the changes in the household consumption of Community Services via the Community Services consumption coefficient. This consumption coefficient is usually estimated using actual household consumption data (for example, the ABS Household Expenditure Surveys).

TABLE 4.7 SERVICE EMPLOYMENT-POPULATION RATIOS. 1974-1980[a].

	1974	1977	1980
Canada	.135	.148	.156
United States	.136	.148	.142
Japan	.088	.092	.092
Germany (Fed. Republic)	.084	.099	.098
Australia	.077(1971)	.100(1976)	.109(1979)

(a)Service employment is defined as Category 8 of the International Labour Office Industry Classification, namely commercial, social and personal services.

Source: International Labour Office Yearbook. United Nations (1982).

However, such an approach will produce erroneous forecasts, since it fails to acknowledge that the provision of a large proportion of services is not dependent on a cash flow from the public (Jones and Murdock, 1978). Moreover, even when this is the case, the relationship between dollars spent and services provided is a weak one. For instance, on a number of occasions during the period 1971-76, household expenditure on health services was radically affected by changes to health insurance provisions, although employment in the health sector was virtually unaltered by any of these changes. An empirical example will help clarify this argument. Between 1968-69 and 1974-75 the national input-output tables show that private consumption expenditure on public administration increased in real terms by 24 percent. However, employment in the same sector over the same period increased by 38 percent.

The tendency of the simple input-output model to underestimate service sector impacts when household cash flows are used to to construct consumption coefficients, means that the majority of Australian regional input-output impact forecasts have underestimated service sector impacts. The mechanics of this problem is fairly simple. The household expenditure coefficient for the Service sector ignores the government contribution to Service sector employment. However the employment coefficient for the Service sector is calculated using the total output of the sector-that is government expenditure is included. When this coefficient is applied to the inverse coefficients, the resultant sectoral multiplier must always underestimate real-life impacts.

Thus, there are two serious problems that impair the ability of the simple input-output model to produce accurate impact forecasts for the service sector. An example will help illustrate these. Consider the case of a regional scientist attempting to produce an impact analysis of a factory which is to be located in a small Australian region in 1984, using an input-output table for the year 1976. If the table was closed with respect to households, the impact forecasts would be erroneous for two reasons. Firstly, the analysis would not allow for the increase in the size of the service sector between 1976 and 1981. Secondly, if cash flows from the household sector were used to construct the consumption coefficients, the forecasts would underestimate the employment linkages to the service sector.The seriousness of this problem should not be underestimated. For many Australian regions, major multiplier impacts of new developments are experienced in the Service sector. For example, Jensen and West (1983) in a survey of twenty nine Australian regional input-output tables, examined the sectoral incidence of flow-ons effects. The Personal Services sector was ranked second to the Trade sector in importance.

Furthermore, it is considered that a solution to this problem cannot be found by "tinkering" with the input-output model. Steps might be taken to impute a more realistic consumption coefficient for the service sector, but the problem remains of adjusting for changes in this coefficient from the time the table is compiled and the year for which the impact analysis is calculated. This adjustment is necessary to allow for the continual change in the size of the Service sector. Alternatively, attempts could be made to compensate for the underestimation of Service sector employment by treating the increase in public final consumption expenditure in the region as an increase in final demand. However, estimating public final consumption expenditure involves an enormous data gathering exercise, especially when it is considered that the expenditure would have to be expressed net of private final consumption contributions to avoid double-counting.

4.8 CONCLUSION

This chapter provides what is considered to be a relatively comprehensive test of the simple input-output model. The findings reveal that after making allowances for large increases in Service sector employment, the model performed reasonably well at the aggregate level. However, as discussed in Section 4.5. the presence of confounding factors means that a completely uncontaminated test of the impact forecasts is not possible. Rather, the aim of this Chapter has been to identify those instances where traditional applications of input-output models may be generating inaccurate forecasts. Examined in this light, the results of the evaluation of the Broken Hill input-ouput model contain three lessons for users of input-output tables.

First,the disaggregated sectoral multipliers generated using input-output tables are likely to contain large errors. For this reason, it might be wiser to view these multipliers as ranking measures rather than as definitive sectoral impact estimates. This finding has important implications for the utility of the GRITSSIC technique which was discussed in Chapter 3. It was demonstrated in that chapter that the GRITSSIC technique was unable to generate accurate disaggregated multiplier estimates. Since the accuracy of these survey-based disaggregated multipliers now seems open to question, it no longer seems appropriate to require semi-survey techniques to "accurately" generate disaggregated multipliers.

The second lesson is that a large number of Australian impact studies to date have seriously erred in the estimation of construction sector impacts since impacts resulting from capital expenditure have been ignored. This problem can be overcome if increased capital expenditure relating to the construction sector is estimated separately. Since a major component of this expenditure will typically be housing outlays, the accurate estimation of this figure would be aided by a population forecast for the region.

The third, and most important lesson, is that an alternative approach has to be found for modelling changes in Service sector employment in a region. The simple input-output model is incapable of reliably forecasting impacts in these sectors, and it would seem that alterations to the input-output model to remedy this problem would be extremely cost-inefficient. This is a serious problem since for many non-metropolitan Australian regions, major impacts associated with new developments will be experienced in the service sector.

In conclusion, it is considered that this chapter has provided some useful insights into the deficiencies and ways of improving the accuracy of impact forecasts based on inputoutput models. It is hoped that this will result in a sharpening of the input-output model as a policy tool, and lead to a greater awareness of the dangers of treating the input-output model as a magic black box.

CHAPTER FIVE.

SERVICE SECTOR IMPACTS

The main lesson for input-output analysts to be drawn from the discussion in the previous chapter is that the simple input-output model is incapable of adequately treating service sector impacts. The aim of this chapter is to explore ways of overcoming this serious shortcoming by developing a model, capable of being interfaced with input-output analysis, that accurately predicts service sector impacts. The basic conceptual thrust of the model is that the estimation of service sector impacts is best accomplished by critically examining the link between population and service employment. That is, it is considered that service sector jobs are "population driven", rather than being linked to income levels in a region as traditionally postulated in input-output models. Accepting this basic hypothesis, the Chapter first examines previous research into the relationship between population and service employment. On the basis of this review, a service employment-population model (SEPM) is developed and tested using Australian Census data.

5.1 REVIEW

The link between population and service employment has long been of interest to regional scientists, and in particular to geographers. The 1960's saw a number of studies quantifying this relationship, the most notable being the research by Berry,Barnum and Tenant (1962). In their study of southwestern Iowa, they estimated the product moment correlation between the population of a centre and its number of functional units (a measure of the availability of services) to be 0.98. However, the study like the many others was descriptive, merely quantifying the existing situation rather than attempting to establish relationships within a predictive framework.

This was not the case with the so-called minimum requirements approach developed by Ullman and Dacey (1962). This technique involves firstly dividing all cities within an area into groups according to their population size, with each group containing cities of about the same range in population size. Then, for any service activity, the city in each group that has the lowest proportion of its employment in that particular service activity is considered to represent the minimum requirement for an industry in a city of that particular size range.

Whilst such an approach is considered an interesting attempt to quantify the population-service employment relationship, for a number of reasons the method does not have the precision to measure the impact of a change in population on employment in the service sector. Firstly, there is a very strong danger that an abnormal urban area may be chosen to establish the minimum requirements for that particular size of city. (Yeates and Garner,1971;129). Secondly, and more importantly, the minimum requirements curves are essentially functions that estimate the average propensity of employment to change with changes in population. However, predicting the impact of a change in population involves forecasting changes at the margin. Economies of scale would suggest that marginal values are substantially different from average values.

More recently, a number of studies have focussed more specifically on the relationship between public sector employment and population. For example, Davis and Webster (1981) contend that previous impact studies have suffered from the lack of coordination between their demographic and economic components. They argue that a detailed knowledge of in-migration is crucial in determining public sector employment since:-

> "The number of public sector employees in a community is more a function of the total population than it is of the community's total income" (1981,160)

Unfortunately, in an empirical application of their composite socio-economic model they use a 1:8 ratio of public employment to the number of <u>employed</u> in-migrants - an assumption in stark contrast with their earlier statements. Nevertheless, Davis and Webster's work is important in acknowledging the role of population as an employment generator.

A number of impact studies undertaken in the USA, have avoided the mistake of Davis and Webster and empirically measured public sector impacts by developing public sector employment-population ratios (Gilmore <u>et al</u>,1975; Intermountain Planners and Wirth-Berger Associates,1974;Stenehjem and Metzger,1976). Whilst the mechanical simplicity of this approach has a certain appeal, such a procedure cannot be considered as a viable model for estimating service sector impacts for a number of reasons.

Firstly, the simple population-public sector employment ratio approach does not have a mechanism for adjusting the ratio over time. The analysis in Chapter 4 made it quite clear that one of the problems with the traditional input-output model is that it does not make allowances for rapid growth in the Service sector over the last ten years. The simple public sector ratio approach suffers from a similar weakness since none of the applications of the model have made allowances for the changing size of the population-public sector employment ratio.

Secondly, the SEPM cannot be exclusively concerned with public sector impacts. Some analysts may argue that since the major problems identified in Chapter 4 were the result of services not operating in a true market system, then a service employment-population model should focus on public services. However, the data limitations in Australia make such an emphasis impossible. Public sector by industry data are only available at the State level. Interfacing the SEPM model with a regional input-output table requires an alternative definition of the service sector. Hence the service sector in the SEPM is defined as Division J and K of the Australian Standard Industrial Classification (A.S.I.C.), namely Public Administration and Defence, and Community Services.[1] These are the A.S.I.C. Divisions identified in the analysis in Chapter 4 as the main problem sectors of the simple input-output approach.

Another recent study (Monts and Bareiss,1979), which addressed issues that are very relevant to those discussed here, has a similar sectoral definition problem. This study developed a computerised impact model entitled the Community Level Impact Projection System (CLIPS). Although the employment impact component suffers from its dependance on the export base model, Monts and Bareiss adopt the interesting aproach of using changes in the region's population to estimate changes in 'household serving' employment. Such an approach is consistent with the conceptual stance adopted in this chapter, although a number of factors make this particular approach unsuitable for incorporating into the SEPM. Firstly, there is the sectoral

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[1] As in Chapter 4, these two sectors will be referred to as the Service sector.

definition problem. The household serving sectors include a number of activities that are adequately handled in the input-output framework (e.g. entertainment, retailing), since they operate within a market system. Secondly, the lack of a dynamic component that allows for the increasing importance of the Service sector in the model seriously limits its utility.

In summary, while the link between population and service employment has long been recognised, to date no satisfactory predictive model exists for modelling the impact of a change in population on service sector employment within an input-output framework. The minimum requirements approach, although a useful descriptive concept, lacks the precision to measure the impact of changes at the margin. The more recent studies, whilst highlighting the increasing recognition of population as an explanatory variable in regional employment change, do not provide a satisfactory empirical approach to the problem. As a result, it is considered necessary to devise a model linking population change and employment change in the service sector. The model is developed using Census data for the State of New South Wales, and is subsequently tested using data from Victoria and Queensland.

5.2 CHOOSING A ZONAL SYSTEM AND INITIAL TESTING FOR A RELATIONSHIP.

A recent paper by Openshaw and Taylor (1981) hashighlighted the importance of selecting an appropriate zonal system for model testing. They argue as follows (1981,63):-

> "Different areal arrangements of the same data produce different results, so we cannot claim that the results of spatial studies are independent of the units being used"

The method adopted in selecting a zonal system for the Service employment-population model presented here, follows the optimal zoning approach recommended by Openshaw and Taylor. That is, a number of different zoning systems are used in an attempt to produce the most favourable results for the SEPM. The trial zonal system will be tested using data for New South Wales.

The first zonal system utilised was the Local Government Area (LGA). These are the regions corresponding to the area of Local Council jurisdiction. In 1976 there were 188 non-metropolitan LGA's in New South Wales.[2] The population of these

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[2] This chapter, in line with the overall thrust of the thesis, only considers non-metropolitan regions in the analysis.

varied from 13,8718 to 1,081 in 1976, with a mean of 9678. The link between changes in population and changes in Service employment at the LGA level was examined by performing a regression analysis of population change in the non-metropolitan LGA's with changes in Service employment between 1971 and 1976. The resultant low R^2 of 0.23 strongly suggested that the LGA is not the appropriate scale to examine the Service employment-population relationship. The reason for this would appear to be quite simple. Many people cross LGA boundaries to use services. This results in a level of Service employment in some LGAs which appears excessively large in relation to its resident population. It should also be noted that the results may be affected by the fact that the ABS Census statistics are residence-based.

Therefore it was decided to use a larger areal unit to test the relationship between Service employment and population, namely Statistical Subdivisions. Excluding Sydney, there are 24 Subdivisions in New South Wales, with 1976 populations ranging from 36,3011 to 9,082, with a mean of 72915. However, at the outset it was considered that these areal units could still cause problems, since substantial interregional flows of people occur, particularly between Subdivisions within the same Statistical Division. The severity of this problem is partly related to the criteria used to define the Subdivisions, which are defined by the New South Wales Statistician as:-

"component areas within statistical divisions which have been delineated

> broadly on the basis of topographical and/or climatic features and reflect, inter alia, some degree of homogeneity of agricultural activity" (ABS,1975,5)

That is, Subdivisions are not defined as functional regions that minimize interregional flows. As a result the boundary crossing problem identified in the LGA analysis is again likely to be a problem. For this reason, it is considered necessary to closely scrutinise the spatial variation in the results of any SEPM in order to ascertain whether alterations to the zonal system improve the fit of the model.

The test for a relationship between Service employment and population change between 1971 and 1976, using the Statistical Subdivision as the areal unit, was again undertaken using regression analysis. The data had to be adjusted to allow for the impact of boundary changes between the two censusses. The 1976 Subdivisions were used as the standard, and the 1971 figures adjusted to represent the 24 subdivisions at the 1976 Census. This was accomplished using LGA data as the smallest areal unit. As a result no allowance has been made for boundary changes to subdivisions that resulted in the splitting of a 1971 LGA. Nevertheless, since there was few instances of this between 1971 and 1976, the impact on aggregate figures for subdivisions is likely to be small. Moreover, since data for both variables (Service employment and population) were collected using the same zonal system, the influence on the regression results is likely to be of even smaller magnitude.

The following regression equation was derived from the adjusted data:-

$$E = 513 + 0.180P \qquad \ldots\ldots\ 5.1$$

$R=0.713$ Standard Error=809

where: E = change in Service sector employment between 1976 and 1971.

P = change in population between 1976 and 1971.

The correlation between the predicted values generated by this equation and the actual values is 0.713 (R^2=.51). The R^2 value will be used as a measure of comparison between the results of the regression model and alternative specifications of SEPM.

The above result demonstrates that a significantly strong relationship does exist between the two variables, but that the level of fit for the equation is not good enough to allow the equation to be confidently used as a predictive model. The standard error of the equation of 809 indicates that the 95% confidence limits will allow large variations from the values predicted by the regression equation. Thus, it is clear that an alternative predictive equation is needed.

5.3 MODELLING THE RELATIONSHIP.

In attempting to derive a suitable predictive equation, it is first necessary to examine how changes in Service employment in an area arise. Two issues need to be considered. Firstly, it should be stressed that during times of significant changes in the Service employment-population ratio (SEPR) at the national level (See Section 4.7), large changes in Service employment may occur in an area even when population growth in that area is negligible. This factor is associated with the large constant in equation 5.1. Therefore, a predictive equation needs to have a term that allows for this population independent Service employment change.

The second issue that needs to be considered when deriving a predictive equation is the variation in SEPRs across the States. Obviously different positions relative to major cities, local accessibility considerations and other factors lead to variations in the ratio throughout the State. Table 5.1 lists the SEPRs for the 24 non-metropolitan statistical subdivisions in NSW in 1976. The coefficient of variation of the SEPRs, whilst not high, is still sufficient to generate large errors in a predictive equation that utilised a State average, rather than the individual SEPRs for each area.

TABLE 5.1 N.S.W. SERVICE EMPLOYMENT-POPULATION RATIOS (SEPR'S) AND SEPM RESULTS FOR 1976.

AREA	SEPR	PREDICTED CHANGE IN SERVICE EMP.	ACTUAL CHANGE IN SERVICE EMP.	RESIDUAL[a]	RESIDUAL[b] %
1 Newcastle	.063	5703	5226	-477	- 9
2 Bal of Hunter	.053	932	432	-500	-116
3 Wollongong	.052	2556	3113	557	18
4 Bal of Illaw.	.062	2126	1027	-1099	-107
5 Richmond-Tweed	.065	1754	2188	434	20
6 Clarence	.056	1251	1200	-51	-4
7 Hastings	.054	1254	1301	47	4
8 North Tableland	.088	1257	1091	-166	-15
9 Nortern Slopes	.060	993	1150	157	14
10 North Central	.059	331	469	138	29
11 Central Macq.	.064	814	1152	338	29
12 Macq-Barwon	.052	166	214	48	22
13 Upper Darling	.065	73	170	97	57
14 Central T'lands	.074	1521	1740	219	13
15 Lachlan	.059	824	954	130	14
16 Lower South C.	.052	546	528	-18	-3
17 Snowy	.070	276	298	22	7
18 South T'lands	.089	1694	1974	280	14
19 Central M'bgee	.064	2109	1503	-606	-40
20 Lower M'bgee	.062	516	394	-122	31
21 Upper Murray	.065	994	1026	32	3
22 Central Murray	.063	277	624	347	56
23 Murray-Darling	.050	96	108	12	11
24 Far West	.059	269	314	45	14

Mean: 0.062

Standard Deviation: 0.0099

Coefficient of Variation: 0.16

Absolute Sum of Residuals: 5941

R^2: 0.910

(a) Actual minus predicted Service employment.

(b) Residual/Actual x 100.

Taking these two issues into consideration, the following equation was developed:-

$$E_{76.71}=E_{71}*R_{76.71}/R_{71}+ [(1+R_{76.71}/R_{71})*r_{71}*P_{76.71}] \quad ...... \quad 5.2$$

where : $E_{76.71}$ = Change in regional Service employment 1971-76

E_{71} = Regional Service employment in 1971

$R_{76.71}$ = Change in the Service employment population ratio between 1976-1971 measured on a State wide basis

R_{71} = State Service employment-population ratio in 1971

r_{71} = Serviceemployment population ratio in the Statistical subdivision in 1971

$P_{76.71}$ = Regional population change between 1976 and 1971

This equation is made up of two components. The first term measures the change in service employment resulting from State-wide trends in the SEPR. This term operates independently of population growth in the region. The second term measures the changes in Service employment resulting from changes in population in the region. It does this by adjusting the base period SEPR for the region in line with State-wide trends, and then multiplying the resultant ratio by the population change in the region. Thus the equation specifically allows for the observed ratio differences between regions.

The change in the SEPR value between the two time periods was calculated using Census data. The population and Service employment totals for all regions were summed both for 1971 and 1976, and the difference between the resultant SEPR's then calculated. This procedure revealed that the SEPR had increased by 25 percent between 1971 and 1976. Census data and the SEPR increase were inserted into equation 5.2 and the predicted change in Service employment obtained for each of the 24 Statistical Subdivisions. The estimates, together with other pertinent information, are shown in Table 5.1.

The Table shows, in general, a close correspondence between the actual and predicted values. The correlation coefficient between the actual and predicted values is equal to 0.952-a considerable improvement on the $R=0.713$ obtained from Equation 5.1. Nevertheless, it is considered that the residual errors for a considerable number of regions are still too high to justify the use of the model as a reliable predictive tool. In particular, large errors were generated for the following subdivisions:- Balance of the Hunter, Balance of the Illawarra, Central Macquarie and Central Murrumbidgee.

In an attempt to improve the goodness of fit of the model three procedures were adopted. The first involved the removal of defence force employment (subdivision 71 of the ASIC) from the Service sector, since it is considered that the location of defence employment is related to strategic/political considerations and not necessarily to the population of a region.

In many Subdivisions defence force employment is relatively large and it is considered that inclusion of defence force employment distorts the Service employment-population relationship. The adjusted Service employment values were inserted into Equation 5.2 and the predicted Service employment values were recalculated. The results are shown in Table 5.2. The resulting correlation coefficient between actual and predicted employment is 0.988, a substantial increase over the previous value of 0.952.

The second modification to the model involved the lagging of the increase in population-led Service employment. It was considered that this procedure may improve the fit of the model since Service employment in a non-lagged model may not be able to react fast enough to keep pace with rapid population growth.[3] Intuitively such an approach has appeal, although its

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[3] It should be noted that in the "non-lagged" formulation of the model, lagged effects can still occur. For example, if a large proportion of the 1971-1976 population growth for a region, occured in 1971-1972, then service employment would have until June 1976, to adjust to the new population levels. In this situation the new lagged specificatoin of the model would generate similar results. The lagged model is intended to improve the fit of the model for regions that experienced rapid population growth at the end of the 1971-1976 period.

TABLE 5.2 SEPM RESULTS FOR N.S.W. (1976) AFTER EXCLUDING DEFENCE EMPLOYMENT.

AREA	PREDICT. CHANGE IN SERVICE EMP.	ACTUAL CHANGE IN SERVICE EMP.	RESIDUAL[a]	RESIDUAL[b] %
1 Newcastle	6258	6093	-166	-3
2 Bal of Hunter	830	828	-2	0
3 Wollongong	3077	3391	314	9
4 Bal of Illawarra	1465	1225	-240	-20
5 Richmond-Tweed	2085	2310	225	10
6 Clarence	1463	1273	-191	-15
7 Hastings	1448	1389	-59	-4
8 Northern Tablelands	1552	1214	-339	-28
9 Nortern Slopes	1222	1236	14	1
10 North Central Plains	416	511	94	18
11 Central Macquarie	1013	1237	224	18
12 Macquarie-Barwon	220	229	9	4
13 Upper Darling	109	187	78	42
14 Central Tablelands	1844	1889	45	2
15 Lachlan	1017	1042	25	2
16 Lower South Coast	627	557	-70	-13
17 Snowy	335	328	-7	-2
18 South Tablelands	2016	1995	-21	-1
19 Central Murrumbidgee	1666	1610	-55	-3
20 Lower Murrumbidgee	652	451	-202	-45
21 Upper Murray	1082	1205	123	10
22 Central Murray	350	659	310	47
23 Murray-Darling	119	119	0	0
24 Far West	365	355	-10	-3

Correlation coefficient: 0.988 (predicted with actual)

Absolute Sum of Residuals: 2822

R^2:0.976

(a) Actual minus predicted Service employment.

(b) Residual/Actual x 100.

implementation is associated with a number of problems. Unfortunately, previous research has not addressed the issue of lags in the population-Service employment link, although the work on the timing of multiplier impacts , (Thompson et al, 1979) would suggest that that any lags would be short term rather than long term.

The lag hypothesis was tested by assuming that employment levels in Census years were linked to population levels in the years preceding the Census. The first test assumed that employment levels in June 1976 were related to population levels in June 1975. The SEPM model was applied, resulting in a correlation coefficient between actual and predicted Service employment changes of 0.983. This value is marginally smaller than the corresponding result for the unlagged model, suggesting that the lagging procedure did not result in an improved fit for the model. In the second test the lag period was extended to a two year period. That is, Census employment levels were related to population levels in June, 1974. The resultant correlation coefficient of 0.978 indicated that a two year lag period failed to improve the performance of a lagged model. In the light of these results it was decided not to incorporate a lagged component in the SEPM.

The third modification to the model involved changing the zonal system. As mentioned above, Statistical Subdivisions are not functional units within which inter-regional flows are minimised. Hence distortions in the Service employment -

population relationship are introduced. This is evident from a close examination of Figure 5.1, which shows the location of cities with a population larger than 20000 persons at the 1976 Census, together with the 1976 statistical subdivisions and the subdivisions with large negative residuals. A consistent pattern emerges: Statistical Subdivisions with large negative residuals are contiguous with Subdivisions containing cities of 20000 or more. These include the Balance of the Illawarra, Hastings and the Northern Tablelands. The larger cities most probably attract people across Subdivision boundaries generating positive residuals in the attracting Subdivisions and negative residuals in the adjacent areas. In terms of Central Place Theory, consumers are moving across Subdivision boundaries to acquire higher order goods and services at higher level centres in the hierachy (See, for example, the work of Holmes and Pullinger (1973) on the trade area of Tamworth).

This pattern suggests that modifications to the zonal system could substantially improve the goodness of fit of the model. However, a word of caution needs to be inserted here. Since ultimately the SEPM will be nested with an input-output model it is necessary to ensure that the spatial systems of both models are compatible. Unfortunately, confidentiality restrictions of the ABS limit the spatial breakdown of data that is a necessary input into the GRITSSIC formulation. For this reason, it is considered that a major reorganisation of the spatial units used in developing the SEPM would be counterproductive, since it would generate a zonal system that is not compatible with GRITSSIC

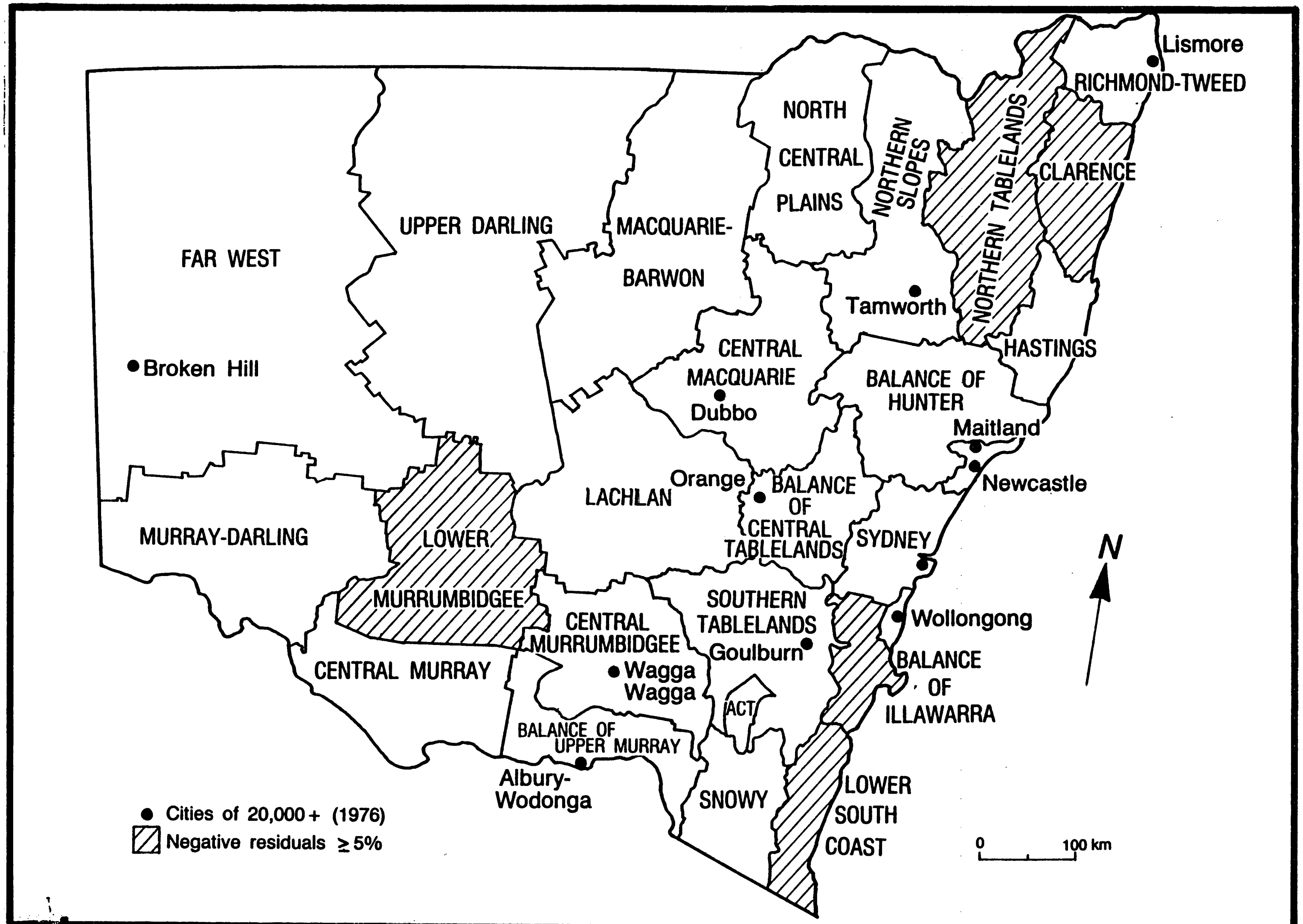

FIGURE 5.1 DISTRIBUTION OF RESIDUALS - NEW SOUTH WALES

regional input-output models. Instead, a minor reorganisation of zonal boundaries is proposed based on the following assignment procedure: Statistical Subdivisions adjacent to Subdivisions within the same Statistical Division containing cities in excess of 20000 persons in 1976 are incorporated with the adjacent Subdivision.

In this way, the following Subdivisions are amalgamated:-

(a) Newcastle-Balance of Hunter (Hunter)

(b) Wollongong-Balance of Illawarra (Illawarra)

(c) Northern Tablelands-Northern Slopes-North Central Plains (Northern)

(d) Central Macquarie-Macquarie Barwon (Macquarie)

(e) Central Tablelands-Lachlan (Central West)

(f) CentralMurrumbidgee-Lower Murrumbidgee(Murrumbidgee)

(g) Central Murray-Upper Murray (Murray East)

It should be noted that subdivisions within the South Eastern Statistical Division are not amalgamated despite the location of Goulburn (1976 population 21735 persons) in this Division. This is because the regional influence of Goulburn is overshadowed by the location of Canberra, the nation's capital, in the centre of the Division.[4]

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[4] Canberra is located in the Australian Capital Territory which is not part of New South Wales (See Figure 5.1).

Using data for the 16 revised regions and Equation 5.2, the predicted changes in Service employment were generated and are shown in Table 5.3. The Table clearly shows that the revised zonal system results in an improvement in the fit of the model. The value of the correlation coefficient increased from 0.988 to 0.995.

However, despite the strong overall relationship, some areas still exhibit large residuals (For example, Upper Darling and Murray East). However, it seems unlikely that any further modifications to the model will reduce these residuals. The process of the location of Service employment is such that it is not possible to specify a model that resulted in an an excellent fit for <u>all</u> regions. There is a particular problem with small regions, since the siting of one activity (e.g. a new school) contrary to model predictions, may be enough to generate large errors in any specification of the SEPM. Moreover, previous research on the siting of public facilities in Australia , has shown that decisions are often made in the light of political considerations, rather than on the basis of need (Phibbs,1976). Such political decisions could easily distort simple needs-based models such as the SEPM shown in Equation 5.2. This political dimension of public facility location is well summarised by Jones and Murdock (1978,955) who state that the level of public facilities is influenced by :-

> "a complex interaction of the interests of
> individuals, associations, elected offici-

TABLE 5.3 SEPM RESULTS FOR 16 NSW REGIONS (1976) AFTER EXCLUDING DEFENCE EMPLOYMENT

AREA	PREDICT. CHANGE IN SERVICE EMP.	ACTUAL CHANGE IN SERVICE EMP.	RESIDUAL[a]	RESIDUAL[b] %
1 Hunter	7382	7209	-173	-2
2 Illawarra	4599	4766	167	4
3 Richmond-Tweed	2085	2310	225	10
4 Clarence	1463	1273	-191	-15
5 Hastings	1448	1389	-59	-4
6 Northern	3320	3095	-225	-7
7 Macquarie	1282	1523	241	16
8 Upper Darling	109	187	78	42
9 Central West	1844	1889	45	2
10 Lower South Coast	627	557	-70	-13
11 Snowy	335	328	-7	-2
12 Southern Tablelands	2016	1995	-21	-1
13 Murrumbidgee	2418	2159	-259	-12
14 Murray East	1464	1916	453	24
15 Murray-Darling	119	119	0	0
16 Far West	365	355	-10	-3

Correlation coefficient: 0.995 (predicted with actual)   Absolute Sum of Residuals: 2270 R^2: 0.990

(a) Actual minus predicted Service employment.

(b) Residual/Actual x 100.

als and public agencies"

In order to investigate the political dimension in the location of Service employment, electoral records for the 1973 State Legislative Assembly[5] were examined and the marginal seats after this election were identified. Marginal seats were defined, for the purposes of this exercise, as the seats requiring the distribution of preferences to obtain a result. The statistical subdivision that contained the greatest proportion of the registered voters in each of these marginal seats, together with the residuals for these subdivisions from Table 5.2, are listed in Table 5.4. The statistical subdivisions, rather than the 15 amalgamated areas, are used in this analysis to enable easier correspondence of the marginal electorates with the subdivision boundaries.

Table 5.4 suggests that political considerations influenced the siting of Service employment in New South Wales in the 1971-1976 period. The table shows, for example, that all the marginal seats with Government incumbents, correspond with subdivisions

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[5] State government employees, particularly in the health and education sectors, comprise a large proportion of non-metropolitan Service sector employment (Unfortunately, no A.B.S. data are available).

TABLE 5.4 MARGINAL SEATS AFTER THE 1973 STATE ELECTIONS AND THE SIZE OF THE RESIDUALS IN TABLE 4.2

Marginal Seat	Party of Incumbent	Corresponding Subdivision	Residual no.	Residual %
Burrendong	Government	Central Macq.	224	18
Murray	Government	Cental Murray	302	48
Burrinjuck	Non-govern.	Central Murrum.	- 55	- 3
Casino	Non-govern.	(a)	(a)	
Murrumbidgee	Non-govern.	Lower Murrum.	-194	-47
South Coast	Non-govern.	Lower South C.	- 67	-13

(a) Since the Casino electorate cut across three subdivisions it was impossible to isolate a single subdivision corresponding with this electorate. As a result the residual figures are not included.

possessing significant positive residuals. Moreover, all the marginal seats with non-government incumbents, correspond with subdivisions possessing negative residuals. Whilst no causal relationship can be deduced from these figures it would seem unlikely that such a pattern is merely the result of coincidence.

In addition to this political factor, Governments might also apply positive discrimination policies in economically disadvantaged regions. For example, public employment may be increased in regions to counteract a declining industrial base. Application of such policies would also introduce distortions to the SEPM.

In summary, both these factors suggest that further modifications to the SEPM will not significantly reduce the residuals shown in Table 5.3. Indeed, the results shown in that table are perhaps too good, and they possibly represent the exception rather than the rule. In order to examine this hypothesis, the SEPM was tested using data from Queensland and Victoria.

TESTING THE SEPM USING QUEENSLAND AND VICTORIAN DATA.

(a) Queensland.

The SEPM (Equation 5.2) was applied to adjusted Queensland data for the 1971-1976 period. The data were adjusted using the procedures described in the previous section. The amalgamation of Statistical subdivisions resulted in data for 10 areas being analysed.

The results of this analysis are shown in Table 5.5. The correlation coefficient between actual and predicted Service employment changes is equal to 0.958. Figure 5.2 shows the the location of the ten zones and the population of the major urban centres. The map suggests reasons for the large discrepancies between the actual and forecast values for the Central West and

TABLE 5.5 SEPM RESULTS FOR QUEENSLAND (1976)

AREA	PREDICT. CHANGE IN SERVICE EMP.	ACTUAL CHANGE IN SERVICE EMP.	RESIDUAL[a]	RESIDUAL[b] %
1 Moreton	4228	4946	718	15
2 Wide Bay-Burnett	2201	2320	119	5
3 Darling Downs	2176	2280	104	5
4 South Western	169	109	-60	-55
5 Fitzroy	1928	2116	189	9
6 Central West	117	-74	-191	-258
7 Mackay	1118	730	-388	-53
8 Northern	2839	2715	-125	-5
9 Far North	2322	2456	134	5
10 North West	357	475	119	25

Correlation coefficient: 0.958 (predicted with actual)   Absolute Sum of Residuals: 2147 R^2: 0.918

(a) Actual minus predicted Service employment.

(b) Residual/Actual x 100.

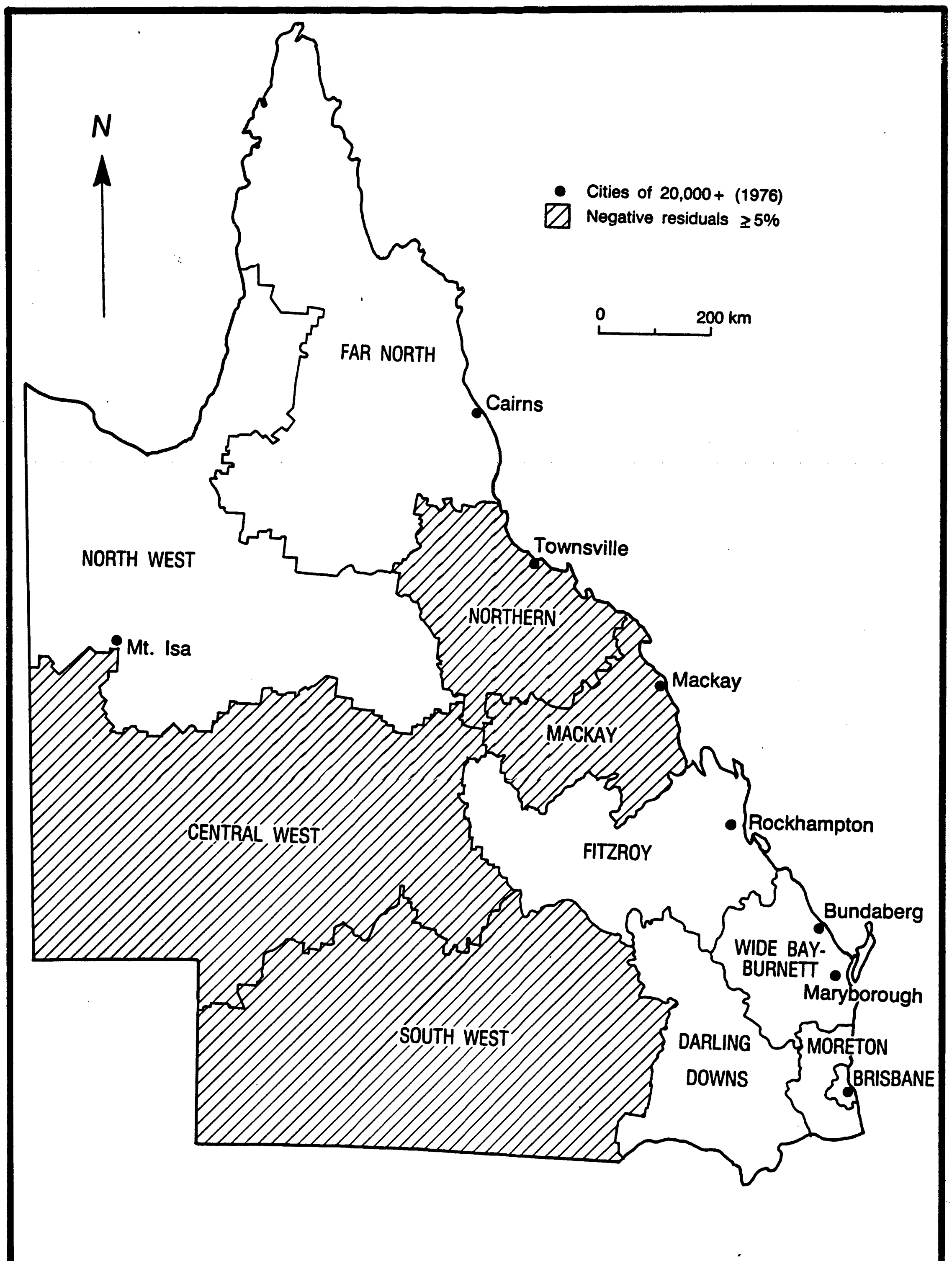

FIGURE 5.2 DISTRIBUTION OF RESIDUALS - QUEENSLAND

Mackay regions. The Central West Statistical Division's northern boundary is in close proximity to Mt. Isa, the second largest inland city in the State. (Population of 25377 in 1976). As a result there would be a substantial flow of people crosssing this boundary to use the Services provided in Mt. Isa, generating the positive residual in the North West region and the negative residual in the Central West.

In the case of Mackay, Figure 5.2 reveals that a significant flow of people are likely to cross the southern boundary of the Northern Statistical Division to travel to Rockhampton. This boundary crossing could be attributed to two factors. Firstly, Rockhampton's greater population (Rockhampton in 1976 had a population of 50132 in comparison to Mackay's 31522 persons) would be associated with a greater range of available services. Secondly, Mackay's northern location in the Division means that Rockhampton would be closer than Mackay for people located in the southern portion of the Division. This situation was the result of a boundary change in 1974, which moved the southern border of the Statistical Division approximately 100 kilometres south. This change was instituted by the ABS in order to ensure that the Statistical Division boundaries remained consistent with the State Government's Planning Regions, declared in the October, 1973.

Thus, if the zonal system is altered the two large residuals associated with the Mackay and the Central West are substantially decreased. However, for the reasons stated in the previous section, it is not feasible to make the necessary adjustments to the zonal system. If such adjustments were made then it would appear that the Queensland data would produce results, in terms of goodness of fit, of the same order as the New South Wales case.

(b) Victoria.

The SEPM (Equation 5.2) was applied to adjusted Victorian data for the 1971-1976 period. The data were adjusted using the procedures described in the previous section. The amalgamation of Statistical subdivisions resulted in data for 13 areas being analysed. The results of this analysis are shown in Table 5.6.

The correlation coefficient betwwen the actual and predicted Service employment changes is equal to 0.981. Figure 5.3 shows the location of the thirteen zones and the population of the major urban centres. The map suggests that the reasons for the discrepancies between the actual and forecast employment figures for anumber of areas is the result of a trade shadow effect.[6] The large negative residuals for both the Albury-Wodonga Statistical District(part) and the North Eastern Statistical Division, are likely to be related to the close proximity of Albury, across the New South Wales border. Albury, with a

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6 (For a discussion of the trade shadow effect in the Australian situation see Smailes (1969).

TABLE 5.6 SEPM RESULTS FOR VICTORIA (1976)

AREA	PREDICT. CHANGE IN SERVICE EMP.	ACTUAL CHANGE IN SERVICE EMP.	RESIDUAL[a]	RESIDUAL[b] %
1 Barwon	3356	3459	103	3
2 South Western	1537	1304	-233	-18
3 Central Highlands	2192	2048	-144	-7
4 Wimmera	765	941	175	19
5 Northern Mallee	951	995	44	4
6 Loddon	2638	2648	9	0
7 Goulburn	1855	1943	88	5
8 Albury-Wodonga	864	464	-400	-86
9 Bal of North East	970	794	-177	-22
10 East Gippsland	656	688	32	5
11 Morwell	-61	-54	7	-13
12 Bal of Central Gippsland	1711	2093	382	18
13 East Central	520	469	-51	-11

Correlation coefficient: 0.981 (predicted with actual)   Absolute Sum of Residuals: 1845 R^2: 0.962

(a) Actual minus predicted Service employment.

(b) Residual/Actual x 100.

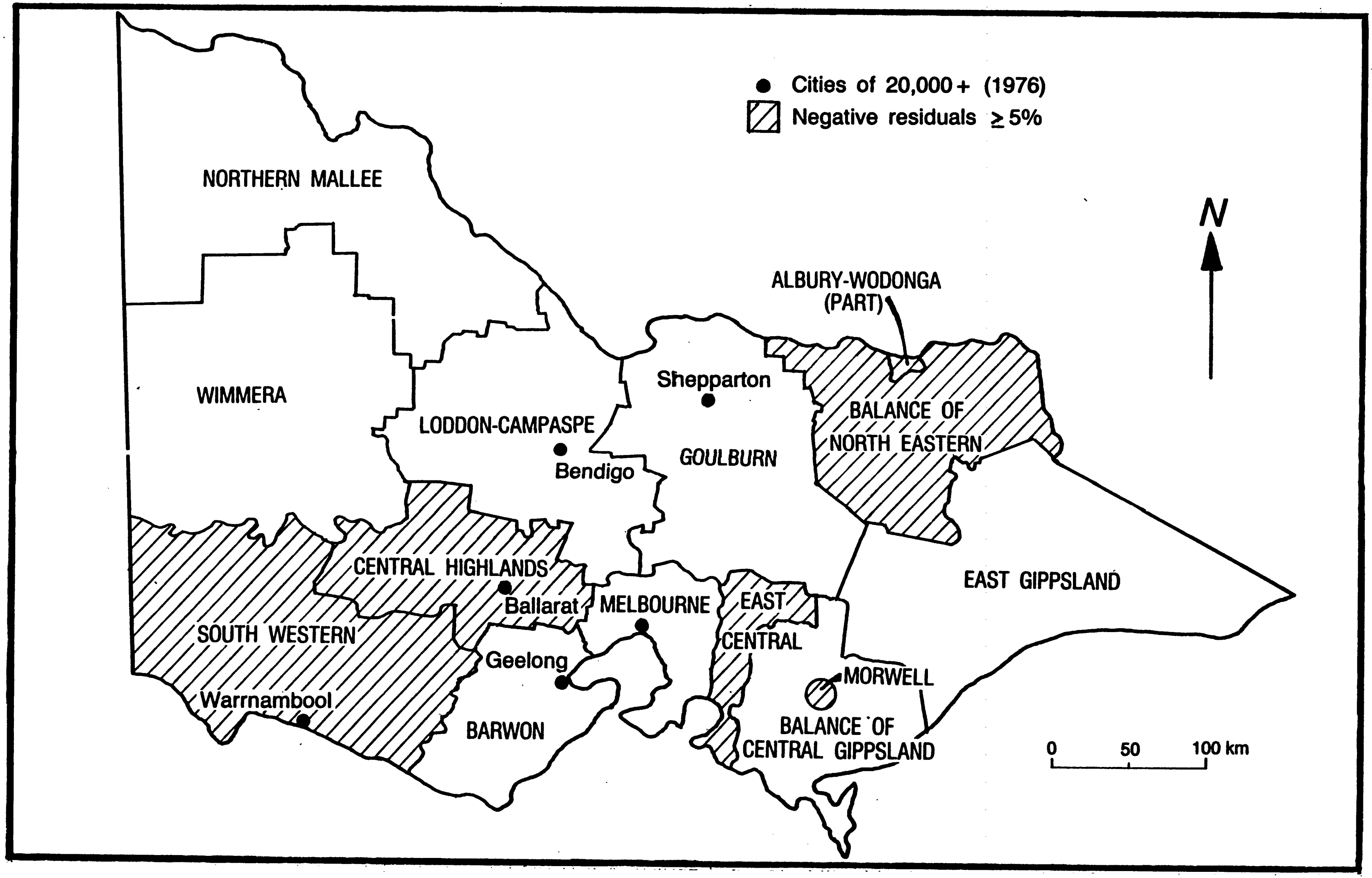

FIGURE 5.3 DISTRIBUTION OF RESIDUALS - VICTORIA

population of 31954 in 1976, would generate a large number of service-related border crossings.

Figure 5.3 also reveals the influence of Melbourne, the capital city. In 1976 Melbourne had a population of 2479225, which represented 66.2 percent of the total State population. The negative residual associated with the Central Highlands Statistical Division is likely to be generated by people crossing the Division boundaries into Melbourne.

Finally, the relatively large negative residual for the South Western Statistical Division is likely to be the result of people crossing the divisional boundary to the higher order centre of Geelong (122080 persons,1976) and Ballarat (60737 persons,1976). By contrast, the population of the largest urban centre in the Division, Warrnambool, was 20195 persons in 1976.

The results of the analysis for both Queensland and Victoria are generally consistent with the results for New South Wales. These findings strongly suggest that the SEPM is a reasonable predictor of changes in Service employment. However, before attempting to nest the SEPM model into an input-output framework, it is necssary to test the model using data from a different time period, since in many ways the 1971-1976 period could be considered atypical, being dominated by the expansionist policies of the Federal Labour Government which led to a rapid and unprecedented expansion of the Service sector. The period chosen is the 1976-1981 time period.

TESTING THE SEPM FOR THE 1976-1981 PERIOD.

The revised SEPM model was tested using Census data for the 1976-1981 period. Adjustments were made to the data to allow for boundary changes between the two periods. The results for New South Wales, Queensland and Victoria are shown in Tables 5.7 to 5.9 respectively.

A general trend that emerges from the information in these tables is that the correlation coefficients between the actual and predicted values for the 1976-1981 period are significantly lower than those for the 1971-1976 period. This decrease could be attributed to a number of factors.

Firstly, there was a smaller rate of increase of the SEPR between 1976 and 1981. This was largely the result of cutbacks, or in the case of New South Wales, a freeze in Public Service employment,that were instituted in the latter half of this period. Public servants who resigned or retired were often not replaced. This mechanism meant that changes in employment in the Public Administration sector during this period, depended on natural wastage in a region, rather than on the basis of any needs criteria, and as a result it could be expected that the performance of a needs based model, such as the SEPM, would suffer as a result.

The second factor that would cause a poorer performance of the SEPM model in the 1976-1981 period, was the sharp rise in

TABLE 5.7 SEPM RESULTS FOR NSW (1981)

AREA	PREDICT. CHANGE	ACTUAL CHANGE	RESIDUAL[a]	RESIDUAL[b]
1 Hunter	4823	4046	-778	-19
2 Illawarra	2640	3534	894	25
3 Richmond-Tweed	2692	2127	-565	-27
4 Clarence	1517	1145	-373	-33
5 Hastings	1206	1023	-183	-18
6 Northern	1455	1766	311	18
7 Macquarie	907	1203	296	25
8 Upper Darling	63	140	77	55
9 Central West	1175	1728	553	32
10 Lower South Coast	588	503	-86	-17
11 Snowy	300	333	33	10
12 Southern Tablelands	787	1001	214	21
13 Murrumbidgee	1045	1144	98	9
14 Murray East	882	735	-147	-20
15 Murray-Darling	71	93	21	23
16 Far West	106	194	89	46

Correlation coefficient: 0.945 (predicted with actual)

Absolute Sum of Residuals: 4718

R^2: 0.893

(a) Actual minus predicted Service employment.

(b) Residual/Actual x 100.

TABLE 5.8 SEPM RESULTS FOR QUEENSLAND (1981)

AREA	PREDICT. CHANGE IN SERVICE EMP.	ACTUAL CHANGE IN SERVICE EMP.	RESIDUAL[a]	RESIDUAL[b] %
1 Gold Coast	3332	2795	-538	-19
2 Bal of Moreton	3455	3739	284	8
3 Wide Bay-Burnett	2152	1919	-232	-12
4 Darling Downs	1199	1268	69	5
5 South Western	120	230	111	48
6 Fitzroy	1999	1961	-38	-2
7 Central West	114	266	152	57
8 Mackay	1069	1682	613	36
9 Northern	1672	2501	829	33
10 Far North	2430	1860	-570	-31
11 North West	147	378	231	61

Correlation coefficient: 0.935 (predicted with actual)   Absolute Sum of Residuals: 3667 R^2: 0.874

(a) Actual minus predicted Service employment.

(b) Residual/Actual x 100.

TABLE 5.9 SEPM RESULTS FOR VICTORIA (1981)

AREA	PREDICT. CHANGE IN SERVICE EMP.	ACTUAL CHANGE IN SERVICE EMP.	RESIDUAL[a]	RESIDUAL[b] %
1 Barwon	3181	3224	43	1
2 South Western	1237	1455	219	15
3 Central Highlands	2190	2026	-164	-8
4 Wimmera	605	604	-2	0
5 Northern Mallee	992	1060	69	6
6 Loddon	2848	2576	-272	-11
7 Goulburn	1896	2082	187	9
8 Albury-Wodonga	790	989	199	20
9 Bal of North East	586	870	283	33
10 East Gippsland	901	841	-60	-7
11 Morwell	167	76	-91	-119
12 Bal of Central Gippsland	2011	1363	-647	-47
13 East Central	624	882	258	29

Correlation coefficient: 0.963 (predicted with actual)   Absolute Sum of Residuals: 2494 R^2: 0.927

(a) Actual minus predicted Service employment.

(b) Residual/Actual x 100.

unemployment. Unemployment at the national level rose from 4.1 percent of the workforce in May, 1976 to 5.6 percent in May, 1981. In times of high unemployment, increased pressure would be placed on politicians to shuffle public sector employment between regions in order to relieve unemployment in certain areas. For example, the large positive residual in the Broken Hill region is mainly the result of a marked increase in public administration employment, which in turn was the politicians' response to the parlous state of the mining industry, the region's main employer.

5.4 CONCLUSION

It is considered that the results presented in this chapter warrant the inclusion of the SEPM in an economic impact model. Whilst the results in the chapter suggest that political considerations and the operation of the natural wastage mechanism in the 1976-1981 period have operated to weaken the empirical fit of the model, it is not considered that the operational usefulness of the model is unduly impaired. This is because such a model could only be expected to demonstrate the most likely impact of a particular economic event in a region. If through the process of direct political intervention or the operation of the natural wastage mechanism, impact forecasts from such a model are in error in certain areas, then the validity of the model is not threatened. Attempting to build these factors into an impact model needs not to be considered, since the very basis of impact analysis is concerned with forecasting the probable impact of a particular development and not attempting to forecast the impacts of political decisions unrelated to the particular activity under consideration. Nevertheless, the usefulness of the SEPM model could be threatened if the factors discussed above, namely the natural wastage and political intervention problem, became so widespread that the correlation coefficient between predicted and actual values was significantly reduced. At this stage, it is considered that such an event is unlikely, but there is obviously a need to monitor the reliability of the model as more data becomes available.

In conclusion, this chapter has finalised the specification of the SEPM and successfully tested it. The problem remains of nesting the model within an input-output framework. This task is addressed in the next chapter.

CHAPTER 6

NESTING THE SEPM WITHIN A DEMO-ECONOMIC MODEL

6.1 INTRODUCTION

In Chapter 3, a method for the generation of cost-efficient regional input-output tables has been established. This technique was verified only by comparison with survey-based input-output tables. A test of the ability of the input-output model to generate accurate regional multipliers was undertaken in Chapter 4. This test highlighted problems with the input-output model and as a result modifications to the GRITSSIC method were proposed at the end of the Chapter. However, despite these modifications, a major problem still remained, namely the inability of the model to accurately forecast changes in Service employment in a region.

This problem was investigated in Chapter 5. A Service employment-population impact model was developed that adequately explains recent changes in Service employment in the three Australian states used to test the model. However, before the model can be used in impact analysis, the model needs to be integrated with the input-output model. This problem is addressed in this chapter, which is structured as follows:- The first section outlines the basic mechanism by which the integration of the two models will be accomplished. In order to assist with the detailed specification of an integrated SEPIM-input-output model the second section reviews a number of demographic-economic models , while the third section describes in detail a demographic-economic impact model that incorporates the SEPIM. The last section provides an example of an application of this model, describing the economic impact of the operation of a coal mine in the Central West region of New South Wales.

6.2 INTEGRATING THE SEPM WITHIN AN INPUT-OUTPUT FRAMEWORK

The first stage in this process involves converting the SEPM model outlined in Chapter 5, into a Service employment-population impact model (SEPIM). The SEPM models changes in total Service employment as a result of population change in a region, while a SEPIM model is concerned with estimating the change in Service employment resulting from population change attributable to a specific economic event.

The conversion process is a simple one, involving the removal of the first term in Equation 5.2 and redefining one of the variables in the second term. The resultant SEPIM model is shown in Equation 6.1 below:

$$E_f = [(1+R_{t+1}/R_t)*r_t*P_f] \ \ldots\ldots \ 6.1$$

where : E_f = Forecast change in regional Service employment

R_{t+1} = Change in the Service employment population ratio between base period and forecast period measured on a State wide basis

R_t =State Service employment-population ratio - base period

r_t = Service employment population ratio in the study region - base period

P_f = Forecast population change in study region resulting from economic event under consideration.

Nesting this SEPIM model within an input-output model seems, on first consideration, a straightforward exercise. The Service sector can simply be removed from the input-output table, the two models run independently, and the results combined to generate the total economic impact of a particular development. However, a major flaw is contained in this approach. When the Service sector is completely removed from the input-output table, the feedback effects or linkages between the Service sector and the remainder of a regional economy are not measured. This problem can be overcome, however, if the following procedure is adopted:-

(a) Set all the Service sector row entries in the direct coefficients table to zero before calculating the traditional Type II impact multipliers. These multipliers could be termed Type IIs multipliers.

(b) Calculate the change in Service employment using the SEPIM.

(c) Estimate the linkages between the Service sector and the remainder of the economy by applying the Service sector Type II multiplier to the change in Service employment generated by the SEPIM.

The use of this procedure then enables the total impacts of a development to be estimated. The next section demonstrates how this mechanism can be placed in an economic-demographic framework, in order to generate realistic regional impact forecasts.

6.3 DEMOGRAPHIC-ECONOMIC IMPACT MODELS

The integration of the SEPIM with the input-output model is an explicit acknwowledgement of the importance of demographic factors in assessing regional impacts. Such an acknowledgement is consistent with recent trends in regional modelling, where attempts to simultaneously model demographic and economic variables have become widespread. One can only agree with Schinnar (1976;455), who states:-

> "There is abundant evidence pointing to the
> fact that demographic variations have been

> induced by manipulations or movements in economic variables, and, conversely, that demographic changes have important "feedback" effects on economic matters"

It should be stressed at this point that this thesis is not concerned with the development of a comprehensive regional demographic-economic model (hereafter referred to as demo-economic models), that could be used to develop comprehensive regional economic and demographic forecasts. Such a task is beyond the scope of this thesis. Rather, the focus in this chapteris on the development of a demo-econmoic <u>impact</u> model, which will enable the simultaneous analysis of economic and demographic factors in undertaking regional impact studies for particular developments. As a result much of the recent literature on demoeconomic models is not directly relevant.

Nevertheless, there is still a wide body of relevant literature, mainly from the United States, where a large number of comprehehsive impact models were developed in the 1970's to analyse the impact of an expansion of the resources sector. A large number of these models contain a specific economic-demographic component. Unfortunately many of these techniques rely on the economic base model, which limits their utility in helping to solve the problem under consideration in this Chapter. (See for example Monts and Bareiss,1979; Cluett <u>et</u>

_al_,1977;Anderson _et al_,1974).[1] Moreover, the models that adopt an input-output framework in their economic modelling suffer from the problem of being unable to accurately measure Service sector impacts, as discussed in Chapter 4. (See, for example, Beckhelm _et al_, 1975).

Nevertheless, despite these limitations in the area of modelling economic impacts, the majority of these models adopt a consistent approach to modelling the demographic-economic interface, which seems suitable for incorporation into a demo-economic impact model. The approach adopted may be summarised as follows:-

The employment demands from the economic model are matched with estimates of labour availability from the demographic model. The supply factor is estimated by applying a labour force participation rate (or a set of rates) to a projected base population. As a result of the matching process, projections of migrating labour are made, based on the imbalance between labour supply and demand. The demographic impacts of migrating workers

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[1] It is intersting to note that some of these models (see, for example, Monts and Bareiss, 1979 andAnderson _et al_, 1974) contained a specific equation in their employment sub-model relating employment (usually called household-serving employment) to population levels. Such an approach is similar to the SEPIM procedure in Chapter 5.

are determined by applying a set of of employment-related demographic characteristics (marital status, number of dependants etc).

Much of the more recent literature is of limited use in assisting in the specification of an appropriate demo-economic impact model, for the reasons already outlined. However a number of recent papers by Madden and Batey (1980,1983) warrant consideration. Madden and Batey build a demo-economic model around an activity-commodity framework, after identifying an inconsistency concerning unemployment in traditional input-output models. This inconsistency is explained in the following terms:-

> "for forecasting purposes, the derivation of a household consumption vector ... relies on a exogenous forecast of household numbers, and some assumption about the unemployment rate of the population making up those households. The consumption .... must then be incorporated into a final demand vector, which ... is premultiplied by the Leontief inverse. From these gross outputs labour demand figures may be obtained by means of coefficients relating employment to gross output. Labour supply is made up of the economically active members of the households whose consumption was incorporated into the final demand vector

> used to generate the forecast. Comparison of labour demand with labour supply yields an unemployment rate which is equal to the assumed rate only by chance" (Batey and Madden, 1981;1067)

One of the major thrusts of the Madden and Batey approach is to remove this inconsistency by specifically including household consumption coefficients for unemployed households. More specifically, Madden and Batey combine the traditional input-output matrix with disaggregated household consumption functions, a sub-model showing the interaction between demographic activities and commodities (e.g. household formation) and a sub-model relating employment to industrial output.

Madden and Batey place the descriptive equations from each of these quadrants into a square matrix and solve the set of simultaneous equations by the usual method of inverting the matrix of coefficients. This process generates multipliers that can be interpreted in the traditional manner. Madden and Batey call these Type 4 multipliers and consider that they will be smaller than traditional Type 2 multipliers since:

> "consumption is treated as an increment - so that people moving into employment from unemployment increase consumption by a margin rather than by the amount they are newly receiving as income (ignoring

savings), and vice versa- we can expect type 4 multipliers to be smaller than type 2 multipliers, but nevertheless larger than type 1 multipliers which ignore induced effects altogether" (Batey and Madden, 1981;1072-73)

Madden and Batey's work clearly represents an important advance on traditional input-output modelling because of its ability to generate more realistic multipliers. The explicit modelling of the unemployed sector assumes added significance as unemployment in Australia and other Western economies continues to rise. Nevertheless, the model does have a number of problems in terms of modelling impacts under Australian conditions. Firstly, the model is data ravenous necessitating a large amount of information in addition to the normal requirements of input-output models. Ledent (1982;38) comments about this problem as follows:-

"from a practical viewpoint, the model involves the use of many variables and parameters for which, owing to the paucity of disaggregate demographic and economic data commonly available at the regional level, pertinent data is not always available."

In particular, the paucity of regional consumption data in

Australia would make the compilation of disaggregated consumption functions an extremely expensive task.

Secondly, the model has not resolved the inconsistencies associated with traditional input-output tables, revealed in Chapter 4. For example, the differences between type 4 and type 2 multipliers may be significantly different when non-market consumption in the Service sector is considered.

Thirdly, the model appears to lack flexibility in relation to the number of flow-on jobs that are taken by unemployed people in a region. The number of unemployed people in each sector who will enter the workforce has to be specified before the model is solved by inversion. However, this number could be influenced by the size of the flow-on impacts. For example, if the flow-on effects are large, there might not be a sufficient number of suitable unemployed people to meet the pre-inversion target, for some sectors.

Before attempting to specify a demo-economic impact model in detail, it is worth examining some work on employment chains by Webster (1979). Webster points out that traditional impact models have assumed that the jobs associated with a development in a region that cannot be taken by the region's unemployed will be taken by people who migrate into the region. Webster, with the aid of an empirical case study, maintains that in practice a number of workers currently employed in the region change employment as a result of "job switching". Migrants and unemployed residents will eventually take the place of those who shift jobs but at a lower level in the employment hierachy than traditional models have assumed. The effect of this employment chaining is to place downward pressure on consumption-induced impacts. This is because a proportion of the extra regional income generated by the development will accrue to those currently employed, whose marginal propensity to consume locally produced goods will be lower than both migrants and unemployed residents. Hence, the operation of chain effects leads traditional input-output models to over-estimate consumption-induced impacts. When this factor is combined with other factors that are considered to generate over-estimation of consumption-induced impacts in traditional models, namely the use of average rather than marginal coefficients, (Blackwell,1978) and the lack of recognition of the unemployed (Madden and Batey,1983), it is clear that the estimation of consumption-induced impacts poses serious problems for tradional input-output models. Unfortunately satisfactory resolution of this problem requires the construction of disaggregated consumption functions, which as previously outlined is usually out of the question in an Australian context due to data limitations. However, incorporation of an employment chain variable would seem plausible within a Madden and Batey type model, and would seem to warrant further investigation in those countries where published disaggregated consumption data is available.

A DEMO-ECONOMIC IMPACT MODEL.

This section specifies in detail a demo-economic model that integrates the SEPIM within an input-output framework. The migration component of the model follows the example set by a number of U.S. models and is estimated after matching labour supply and demand. The model does not include separate consumption functions for the unemployed because of Australian data limitations, although the stage of the model where they could be included is indicated in case the data situation changes. Nevertheless, it is considered that the unemployed have to be incorporated within the model in some manner. It is considered that the most promising option is to adjust the household row coefficients on the basis of the proportion of new jobs that are taken by the unemployed. For example, if the average wage in sector i is $200 per week (the average wage can be calculated by dividing the household income coefficient by the employment coefficient and multiplying by an appropriate constant), and all the new jobs are taken by unemployed, with an average social security benefit of $100 per week, then the household row coefficient is reduced by 50%.

However, the ability of this technique to generate realistic results is limited by the need to specify in advance the number of previously unemployed people who will take up employment in each sector. As outlined above, in the discussion of the Batey and Madden model, the proportion of jobs that go to the unemployed in each sector could be affected by the size of the flow-ons associated with a particular development. This problem is related to the mechanistic process used to solve the input-output system of equations , namely the inversion of the (I-A) matrix. A solution to this dilemna involves using an alternative approach to solve the system of equations, namely the use of the series:- $I + A + A^2 + A^3 + \dots\dots\dots A^n$.

This series was commonly used to estimate input-output multipliers before the widespread use of computers to estimate the Leontief Inverse. The major advantage of the use of the series is that it enables the round by round flow-ons to be estimated. Thus, it is possible to estimate the proportion of unemployed that will be able to enter the workforce at the end of each round by comparing the sex and skill structure of the unemployedwith the sex and skill structure of the flow-on jobs.[2]

The model is best explained by decomposing its structure into a number of discrete modules or stages. These stages are shown in Figure 6.1. and discussed in detail below. In order to simplify the explanation of the model, the various

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[2]. A round by round approach also has the advantage of allowing the analyst to assess whether capacity considerations will lead to bottlenecks in any sectors. In addition if marginal coefficients and data on the amount of job-switching became available, then the round-by-round approach would enable the job-switching chain to be incorporated within the impact model.

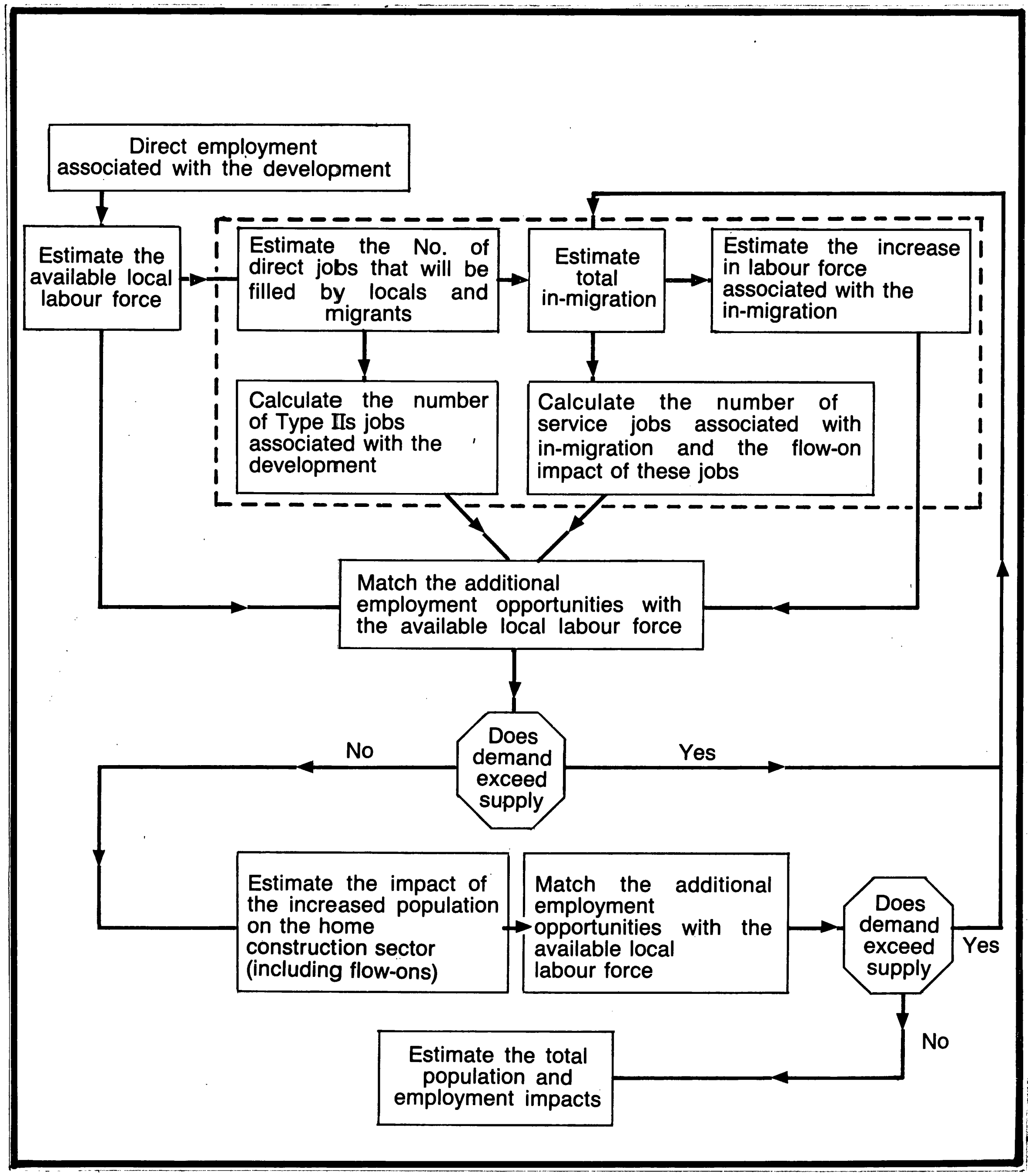

FIGURE 6.1 THE DEMO-ECONOMIC IMPACT MODEL

stages describe the impact of an increase in direct employment. However, the model could be also be used to estimate the impacts of a decrease in direct employment.

Stage 1. Estimate the available local labour force.

The locally available labour force, by sex, is estimated from regional unemployment statistics available from local Commonwealth Employment Service (CES) offices. In addition, female participation rates for the region are compared with the rates of other similar regions, in order to explore the extent of underemployment in the region. An appreciation of the skill characteristics can be gained by a discussion with the local CES officers.

Stage 2. Estimate the number of direct jobs associated with the development that will be filled by locals residents, as opposed to migrants.

The number of local residents who take up direct jobs at the development is estimated by comparing the sex and skill profile of the unemployed with the labour needs of the development. It is assumed that jobs that cannot be filled by local labour will be filled by labour migrating into the region.

Stage 3. Calculate the total in-migration associated with the direct employment effects

Total in-migration is calculated by establishing a demographic profile for the non-local direct employment component of the plant. This profile is derived,where possible, from empirical data for other similar developments in the region. Failing this, data from other regions or a State average is used.

Stage 4 Calculate the additional growth in the labour force due to this migration.

Many simple impact models ignore the fact that some of the dependants of the migrants that take up the direct jobs at the development will also join the labour force. The model quantifies this increase in the labour force by applying an age-specific participation rate for dependant males in the 15-19 category, and a crude participation rate for female dependants. These rates are based on current regional values.

Stage 5. Calculate the number of Type IIs multiplier jobs

An input-output model is constructed using the GRITSSIC technique, with the technical coefficients of the development under consideration usually added as an extra row and column. The Service sector row coefficients are set to zero and the Type IIs employment multiplier for the development are estimated using the $I + A + A^2 + A^3 + \ldots\ldots\ldots.A^n$ series as discussed above. Round by round estimates of the number of unemployed people who will enter the workforce are inserted at the end of each round, and estimates of their foregone social security benefits are made on the basis of their sex and marital status. The household row coefficients are then adjusted downwards accordingly before the calculation of the next round of impacts. If disaggregated consumption coefficients are available for the unemployed, two rows of household coefficients and two columns of consumption coefficients could be included in the model before the flow-ons were calculated, allowing for more accurate estimates of consumption-induced flow-ons. Sex and skill characteristics of the labour force (available from the ABS Census matrix tapes) are used to disaggregate the multiplier impacts by sex and skill (See, for example, Phibbs,1981)

Stage 6. Calculate the number of Service jobs generated by the additional population and the flow-on impacts of these jobs

The total increase in population resulting from the in-migration identified in Stage 3 is fed into the SEPIM and the increase in Service employment estimated. The sex and skill characteristics of these jobs are estimated from the ABS matrix tapes. The flow-on employment, disaggregated by sex and skill level, is calculated using the Type IIs multiplier for the Service sector.

Stage 7. Match the additional employment opportunities with the available local labour force.

Thus far, the supply of local labour is comprised of the local unemployed who did not find employment at the development, plus the additional labour force generated by the in-migration. The demand for local labour includes the Type IIs multiplier jobs associated with the operation of the development under consideration, the Service sector jobs and their flow-on impacts identified in Stage 6.

Since both the demand and supply for labour is available by sex and skill level, it is possible to make reasonable estimates of the demand-supply balance. If demand exceeds supply then it is assumed that further in-migration will occur and hence the modelling process continues. If supply exceeds demand, then no further in-migration will occur and Stages 8,9 and 10 are by-passed.

Stage 8. Estimate the population impact of further in-migration

The total population increase associated with this further migration is calculated by applying a demographic profile to the migrants who move into the region to take up flow-on jobs. Since these jobs will be spread through many sectors, a State average is applied, rather than the more rigourous technique suggested in Stage 3. Since this round of migration is likely to be considerably smaller than the migration related to direct employment at the development, it is felt that this procedure is unlikely to seriously distort the accuracy of the model. The increase in the labour force associated with this further migration is also calculated in this stage (Using a procedure identical to the one described in Stage 4).

Stage 9. Estimate the increase in Service employment and the associated flow-on jobs resulting from this additional in-migration

This increase in employment is calculated using the procedure outlined in Stage 6.

Stage 10. Match the available supply of labour with the additional demand

The demand-supply labour balance is estimated using a similar procedure to Stage 7. If demand exceeds supply then the model reverts back to Stage 8. If this is not the case then the model procedes to Stage 11.

Stage 11. Estimate the impact of the total population increase on the home construction sector

As discussed in Chapter 4, a problem associated with previous Australian impact studies has been the exclusion of capital expenditure for the home construction sector. This stage of the demo-economic model attempts to overcome this problem by estimating the impact of population change on the home construction sector. This estimate is based on the following simple equation, suggested by Buchanan (1981):

$$D = P * S * V \qquad \ldots\ldots\ldots\ldots\ldots \quad 6.2$$

Where: D = Dwelling demand

P = Population increase

S = 1/average household size of migrants

V = 1/% of occupied dwellings

The dwelling demand forecast by this model is converted to an annualised rate and compared with the trend in home completions (available from the ABS). If it is considered that employment in the home construction industry will increase as the result of this increase in demand, the employment change can be estimated with the aid of a number of a number of recent studies that have quantified the labour requirements of the home construction sector (see, for example, Boral Ltd, 1983)

The Type IIs multiplier impacts for the construction sector are added to the direct change in construction employment. Using the method described in Stage 7 an estimate of the labour demand/supply balance is then made. If demand exceeds supply then further in-migration will occur and the model reverts back to Stage 8, otherwise the model proceeds to Stage 12.

Stage 12. Estimate the total population and employment impacts of the development

At this stage the results of the model are summarised by adding total in-migration and the total employment generation described by the model.

6.4 AN EMPIRICAL EXAMPLE

The demo-economic model described in the previous section was utilised to assess the economic impact of an expansion of the Ulan coal mines at Mudgee, in the Central-West of NSW. In particular, the impact of the expansion of the operational workforce of the mine by 128 persons in 1983-84 was examined. The calculations for each stage are described below:-

Stage 1. As of June 30 1983, 994 persons were unemployed in the Mudgee region, being comprised of 729 males and 265 females. It should also be noted that approximately 15% of the unemployed were skilled tradesmen.

Stage 2. The high pool of skilled people that are currently unemployed in the region and the relatively low skill requirements of the development (only about 20% of the coal mine jobs require for skilled labour) suggest that a substantial proportion of the direct jobs will be taken by the unemployed. After consultation with the operators of the mine, a figure of 65% of the jobs going to those previously unemployed was considered reasonable. That is, 83 of the 128 jobs at the mine will go to local unemployed with the remaining 45 being taken by migrants[3]

Stage 3. Total in-migration was estimated by applying a demographic profile to the 45 in-migrants. This profile was based on data from the NSW Combined Colliery Proprietors Association, who conduct regular surveys on the demographic profiles of mine

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[3]. It is quite likely that there may be somejob-switching may occur where local people switch jobs in order to gain the good wages of miners. However, it is assumed that unemployed people will replace these people in their present jobs, and in the absence of marginal consumption coefficients, the estimation of consumption-induced flow ons will not be affected.

workers. Applying this typical demographic profile revealed that the total migration associated with the 45 jobs for migrants would total 130 persons, comprising 32 spouses, 45 male miners, and 53 children (27 female, 26 male with 5 males in the 15-19 age category).

Stage 4. The additional growth in the labour force was calculated by applying a crude participation rate of .315 (calculated using 1981 Census data) to the additional female population of 59, and an age specific participation rate of .61 (calculated using 1981 Census data) to the estimated 5 dependant males in the 15-19 age category. The resultant increase in the labourforce was estimated to be 18 females and 3 males.

Stage 5. The Type IIs muliplier for the mining sector was calculated using an input-output table for the Mudgee-Merriwa shires. The 1-sector GRITSSIC approach was adopted since it was considered likely to be reasonably accurate in this small, undeveloped region. (Total population 15730 persons in 1981).[4] The coefficients for the Service sector were set to zero and the total flow-ons were calculated using the $I + A + A^2 \ldots\ldots A^n$ series. At the end of each round the number of flow-on jobs by sector was estimated. The sex and skill characteristics of these jobs was then estimated using data from ABS Matrix tape

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[4]. For further details of the input-output table see Kinhill Stearns (1983).

21 of the 1976 Census (See Table 6.1) and these data were compared with the sex and skill profile of the unemployed in order to match supply and demand. In particular it was estimated whether the flow-on jobs were taken by :-

(1) unmarried unemployed persons,

(2) married unemployed males,

(3) married unemployed females,

(4) migrants.

The breakdown between the different categories of unemployed workers was necessary in order to make reasonably accurate estimates of the amount of social security benefits foregone by the previously unemployed. For example the unemployment benefit for married males is approximately double that of unmarried recipients, whilst unemployed married females receive no benefits. It was considered that the relatively small number of flow-on jobs, which were mostly relatively low skill jobs in the trade and transport sectors, would be taken by people currently living in the region.

This round-by-round analysis was continued for 5 rounds, at which time the flow-on impacts were less than 1 job. The terms in the series were then added and the employment multiplier calculated in the normal manner. The resultant multiplier was 1.26, meaning that the 128 direct jobs at the mine would generate a further 33 non-Service sector jobs in the region.

Stage 6. The SEPR for the region was calculated to be .0644 in June 1981. On a State wide basis the SEPR has increased by 1.6%

TABLE 6.1. EMPLOYMENT BY SECTOR BY SKILL LEVEL - MUDGEE REGION 1976

Sector	PWC[a]	SWC	SEUWC	SBCME	SBCB	SBCO	SEUBC	RW	0	TOTAL
					Percent					
1. Rural	0.1	0.0	1.3	0.4	0.4	0.4	0.0	96.4	0.1	100
2. Mining	1.6	11.5	6.6	14.8	1.6	0.0	63.9	0.0	0.0	100
3. Food &Beverages	0.0	4.8	8.2	3.2	0.2	28.4	46.7	7.6	0.8	100
4. Textiles,Clothing & F'wear	0.0	16.7	50.0	0.0	0.0	0.0	33.3	0.0	0.0	100
5. Basic Metal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
6. Fabricated Metal Prods	0.0	0.0	12.5	25.0	0.0	0.0	62.5	0.0	0.0	100
7. Chemicals, Petrol. & Coal Prods.	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	100
8. Glass Clay & other Mineral Prods.	0.0	11.8	0.0	0.0	0.0	0.0	88.2	0.0	0.0	100
9. Wood, Wood Prods & Furniture	0.0	0.0	25.0	0.0	0.0	0.0	75.0	0.0	0.0	100
10. Paper & Paper Prods, Printing	0.0	35.7	21.4	0.0	21.4	21.4	0.0	0.0	0.0	100
11. Other manufacturing	0.0	0.0	66.7	0.0	0.0	0.0	0.0	0.0	33.3	100
12. Electricity, Gas & Water	7.0	16.9	25.4	36.6	0.0	0.0	14.1	0.0	0.0	100
13. Building & Construction	0.0	7.0	6.7	11.3	24.6	0.0	47.5	1.4	1.4	100
14. Wholesale & Retail	1.0	15.6	55.3	11.0	0.5	4.4	11.5	0.5	0.2	100
15. Transport, Storage & Comm.	2.4	6.6	12.3	12.0	0.0	0.0	64.8	0.6	1.2	100
16. Finance, Business & Prof. Serv.	12.2	9.9	68.0	0.0	0.0	0.0	9.9	0.0	0.0	100
17. Public Authority & Defence	9.1	10.6	20.7	2.0	4.0	0.0	40.4	8.1	5.1	100
18. Community & Other Services.	14.7	27.0	22.1	0.6	0.8	3.6	29.3	1.6	0.2	100

(a) The skill level groupings are based on the classification of Craigie (1979) (See Phibbs, 1981 in Appendix 1). The skill categories include:

- PWC Professional White Collar.
- SWC Skilled White Collar.
- SEUWC Semi and unskilled White Collar.
- SBCME Skilled Blue Collar (Metal & Electrical).
- SBCB Skilled Blue Collar (Building).
- SBCO Skilled Blue Collar (Other).
- SEUBC Semi and Unskilled Blue Collar.
- RW Rural Workers.
- 0 Other (including the Armed Services).

Source: A.B.S. Matrix Tape Number 21.

beween June 1981 and May, 1983 (based on figures in the ABS publication -The Labour Force- Catalogue number 8203.0). It is considered that given the fiscal constraints of both the Federal and NSW State Governments this ratio is unlikley to increase between May 1983, and January 1984. Thus an adjusted SEPR (.0654) was used to estimate that the additional 130 persons in the region will generate an additional 9 Service sector jobs. The Type II employment multiplier for the Service sector calculated using the round-by-round approach is 1.16, indicating that the 9 Service sector jobs will generate one additional flow-on job.

Stage 7. Stages 5 and 6 identified 43 flow-on jobs. It is considered that the sex and skill profile for these jobs suggests that the majority of these jobs will be taken by local unemployed people. However, it is estimated that because of the higher skill requirements of the Service sector jobs, 4 of these jobs will be taken by migrants.

Stage 8. Using the demographic profile for multiplier jobs suggested by the Department of Environment and Planning, these 4 jobs will generate total in-migration of 12 persons, generating an increase in the female labourforce of 2 persons.

Stage 9. The in-migration of 12 persons will generate a further job in the Service sector.

Stage 10. The one job in the Service sector will be filled by a local unemployed person.

Stage 11. It is considered that the rate of home construction associated with the in-migration will not lead to an expansion of employment in the home construction sector.

Stage 12. In total the initial expansion of 128 jobs directly created by the coal mine operation in 1983-84 will generate an additional 44 flow-on jobs and lead to an increase in regional population of 142 persons.

The 11 stages of the model are summarised in Table 6.2.

6.5 ADVANTAGES AND DISADVANTAGES OF THE DEMO-ECONOMIC MODEL

ADVANTAGES.

The major advantantage of the model is that it avoids the problems identified in chapter 4 concerned with identifying Service sector impacts. Moreover in avoiding these problems it reduces the amount of data relating to private consumption expenditure that needs to be collected. This reduction comes about since no private consumption data is required for the Service sector.

A further advantage of the model is that it acknowledges the presence of unemployed persons within the economic system. Although data limitations restrict the comprehensive modelling of the unemployed, the demo-economic model outlined in this Chapter

TABLE 6.2 THE DEMO-ECONOMIC IMPACT OF THE EXPANSION OF THE ULAN COAL MINES, MUDGEE. 1983-84.

STAGE	LOCAL LABOUR SUPPLY M	LOCAL LABOUR SUPPLY F	CHANGE IN LABOUR SUPPLY.	LOCAL LABOUR DEMAND M	LOCAL LABOUR DEMAND F	SOURCE AND NO. OF JOBS	NO. OF JOBS TO LOCALS	NO. OF JOBS TO MIGRANTS	TOTAL MIGRATION M	TOTAL MIGRATION F
1.	729	265		122	6	128 COAL				
2.	652	259	-77	45		MINE JOBS	83			
3.	652	259						45	71	59
4.	655	277	21							
5.	655	277		20	13	33 IIs JOBS				
6.	655	277		25	18	10 SEPIM JOBS				
7.	634	259	-39	4			39			
8.	634	261	2					4	6	6
9.	634	261			1	1 SEPIM JOB	1			
10.	634	260	-1							
TOTAL IMPACTS						172 JOBS 128 DIRECT 44 FLOW-ON	123 JOBS	49 JOBS	142 PERSONS	

is superior to the traditional input-output approach, and will generate reasonably accurate results, especially for rural regions.

DISADVANTAGES

The major disadvantage of the model is that additional data are required, namely population forecasts and a forecast of likely changes in the SEPR. However, it should be noted that since most impact studies already include demographic forecasts, in most cases no additional work is required. Obviously, a reliance on population forecasts means that impact forecasts of the model are dependent on the accuracy of the demographic analysis. Nevertheless, whilst this procedure will build errors into impact forecasts, the errors associated with thealternative technique, traditional input-output models- are of much greater magnitude.

Impact forecasts based on the demo-economic model also require forecasts of the SEPR. It should be stressed that the analysis in Chapter 5 was based on actual changes in the SEPR. The use of forecast SEPRs will obviously have the potential for generating larger errors than those identified in Chapter 5. Nevertheless, it is felt that the availability of suitable data will allow reasonably accurate forecasts of the SEPR. Firstly, data are available from the ABS on current SEPR values. This means that the current year, rather than a Census year, can be used as a base year for the SEPR forecast. Secondly, governments at both the State and Federal levels are being more explicit about forecast levels of public sector employment. For example, the NSW State Government announces in its annual budget statements the size of the increase in the State Public Service. Thus, it is considered that reasonably accurate forecasts of the SEPR seem plausible.

6.6 CONCLUSION

In this Chapter, a model has been formulated a model for nesting the SEPIM within a demo-economic model based on an input-output framework. The advantage of this new approach is that allows the obvious benefits of the input-output approach to be retained, whilst acknowledging the impact of the unemployed on regional economic systems. In addition the approach remedies the major problem associated with traditional applications of the input-output model identified in Chapter 4, by separately modelling Service sector impacts.

It must be stressed that the aim of this Chapter was not to specify a complete economic-demographic modelling process. Such a task is considered beyond the scope of this thesis. As a result, there has been no attempt to specify in detail the demographic component of the model, or to examine the workings of the model in the more complex situation where a project is developed over a number of years.[5] Nevertheless, neither task would be very difficult, and the result would be a simple but powerful impact model, with limited data requirements. In conclusion, it is considered that the model described in this Chapter has an important policy role in assessing the employment and population impacts of various developments on the economic landscape.

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[5].In such a situation the number of unemployed in the labourforce would have to be estimated rather than merely read from published unemployment statistics.

CHAPTER 7

CONCLUSION

Chapter 1 outlined the three major tasks to be addressed by this thesis. These tasks were :

(1) Review of methodologies for estimating input-output multipliers;

(2) Testing of the input-output model;

(3) Recommending changes to the methodologies selected in (1).

The completion of these tasks has resulted in a number of important findings that have major ramifications for the field of regional impact analysis.

The first of these, based on the analysis undertaken in Chapter 4, is that the model, after a number of adjustments are made to its structure, can produce accurate estimates of regional impacts. This is an important finding, and provides support for a model, which although being widely accepted as an important tool in regional impact analysis, has previously received very little scrutiny by way of empirical testing. This test should allow regional scientists to use impact forecasts based on the input-output model with renewed confidence.

The second major conclusion relates to the preferred method for calculating the regional input-output table. An important finding of the review in Chapter 2 and Chapter 3 is that no one method can be recommended for all situations. A GRIT type model seems the most suitable alternative, and when a major survey effort is required in generating the input-output model, the use of the sum of intermediate inputs as the major data element that is acquired through a survey, (i.e. the GRITSSIC approach), seems to be the most cost-efficient alternative. The major variations in the method relate to the amount of data that needs to be acquired by survey. The review in Chapters 2 and 3 reveals that this depends on the following factors;

(1) The amount of available published data;

(2) The type of region being examined;

(3) The number and type of industries being analysed.

For example, in the case of tables in simple rural regions, where an impact analysis is being undertaken for only one sector which has very weak linkages into the region, then a 1-sector GRITSSIC procedure would be appropriate. That is, a survey of firms in the interest sector would be undertaken in order to estimate the sum of intermediate inputs of the interest sector. If the analysis is being undertaken in a similar region for a sector with relatively strong linkages into the region (e.g. an agricultural processing industry), it would be necessary to obtain detailed information on the direct coefficients of the interest sector. If the same industry was being examined in a larger, more complex region, it may be necessary to obtain estimates of the sum of intermediate coefficients for a number of sectors with strong linkages to the sector under examination. When impact forecasts are required for a number of sectors, rather than a single sector, then the survey data requirements increases accordingly.

Hence, the preferred procedure for estimating the regional input-output table is a matter of judgement for the regional scientist undertaking the analysis. Fortunately, the work of West (1979) provide an important tool in guiding the judgement of the analyst. Whilst the analysis in Chapter 2 indicated that West's sensitivity test algorithm cannot provide a completely accurate list of the most sensitive coefficients, it still can be an important guide for indicating the most cost-efficient approach to survey based data gathering, particularly when the analyst is only interested in analysing the impact of a single sector. An important element of the work of West (1979) and the sensitivity tests carried out in Chapters 3 and 4 of this thesis, has been to highlight the relative insignificance of non-impact direct coefficients on input-output multipliers. Or in other words, for many Australian regions the multiplier values are dominated by the direct and first round effects, and hence errors in the remaining direct coefficients of the input-output table, with the exception of the private consumption coefficients, have very little impact on the accuracy of the multiplier in question. Hence, a cost-efficient approach to constructing regional input-output tables for single sector impact studies would require that little effort is used in estimating these insignificant direct coefficients, but instead resources are concentrated on the more significant direct coefficients.

The third major finding of the thesis is that accuracy of impact forecasts are improved if Service sector impacts are not estimated using the traditional input-output model, but instead are forecast using a simple Service employment-population model which is developed and tested in Chapter 5. The large errors associated with forecasting Service sector impacts using traditional methods are the result of two factors, namely:

(1) The location of these industries within the Public sector of the economy;

(2)The changes in the size of the Service sector that are exogenous to the model.

A methodology suitable for incorporating the simple Service employment-population model within an input-output framework was outlined in Chapter 6.

A number of findings, based on the evaluation of the input-output model undertaken in Chapter 4, have important implications for the methods used to undertake impact forecasts and the way these forecasts are presented. Firstly, an important conclusion from Chapter 4 is that detailed sectoral impact forecasts should be treated with suspicion. The restrictive assumptions of the input-output model generate errors in the sectoral impact estimates that tend to cancel each other out when total impacts are considered. Thus, it seems reasonable to suggest that the regional analyst should present a more qualitative discussion of sectoral impacts, rather than presenting detailed sectoral impact forecasts. Secondly, the analysis in Chapter 4 suggested that the accurate specification of regional impacts requires a closer examination of the construction sector, in particular the housing construction sector. The simple input-output model, because of its concentration on current rather than capital costs, ignores the impact of home construction. However, in many regions home construction can be an important source of employment in a region, and thus it would seem appropriate to make a separate estimate of the impact of population increase/decline on home construction, and estimate the impact of any changes in the level of home construction using the relevant input-output multiplier.

The study is not without its weaknesses and shortcomings. In concentrating on the simple static input-output model its has had a narrow focus. However, as discussed in Chapter 1, such a strategy is linked with the focus of the thesis on the Australian situation.

Secondly, in attempting a wide-ranging review of the simple static model, testing its predictive behaviour and suggesting a major change in the method for calculating regional input-output multipliers, the study has covered a broad range of topics within impact analysis, and in some cases has asked more questions than it has answered. For example, the sensitivity analysis in Chapter 4 highlighted the importance of household coefficients for determining multiplier values. However, as has been indicated a number of times in this thesis, the amount of regional consumption data available in Australia is very limited, and regional consumption coefficients are usually estimated by indirect means. It has not been possible within the scope of this study to investigate private consumption data, although it is clear that it is an important area for further research. Such research should assess the accuracy of the indirect estimation methods for consumption coefficients, and , if necessary, suggest cost-effective alternatives.

One of the conclusions that one could make from a methodological viewpoint concerning the research presented in this thesis is that the empirical evaluation in Chapter 4 generated a great deal of information about the regional input-output model, highlighting a number of areas where traditional approaches to the estimation of regional input-output multipliers were inaccurate. Hence, it is considered important that where possible, the accuracy of impact models should be assessed by empirical studies. The old adage "the proof of the pudding is in the eating" applies to both pudding and impact models and regional scientists can hardly be suprised at the cynicism of the "hard-nosed" policy makers about sophisticated impact models, when the modellers have shown little interest in evaluating their creations. In order to achieve more widespread support amongst policy makers, impact analysts need to provide empirical evidence that their models are reasonable and offer a cost-effective alternative to the "educated-guess" approach adopted by many policy makers and their advisors in Australia. As was discussed in Chapter 4, this evaluation process is not an easy one. In order for it be successful, it is necessary to establish, in suitable regions (such as Broken Hill), monitoring systems of key variables. The predictions of impact models could then be compared with actual changes in economic variables. This task seems to be the next major challenge of regional impact analysis.

APPENDIX 1.

REPRINTS OF RELEVANT PAPERS

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A shortcut method for computing final demand multipliers for small regions

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Abstract. In recent years substantial interest has developed in shortcut methods for estimating final-demand multipliers. This paper proposes a procedure which simplifies the mathematical formulae for such multipliers. It is considered that the procedure developed is most appropriate for investigating interindustry relationships of small regions, and its greatest advantage lies in its value as a resource saving alternative to traditional input-output final-demand multipliers.

Introduction

Although input-output analysis is becoming increasingly popular as an analytical and planning tool at the regional level, regional economists who use input-output analysis are continually faced with the problem of data acquisition and availability. Indeed, as Smith and Leigh (1977, page 131) also observed in a recent review paper, data availability can be a crucial factor in the selection of a member of the family of regional economic models. In the case of input-output analysis, considerable financial resources are invested in the collection of data to estimate interindustry relationships, and where such resources are very limited the technique is often discarded. For this reason any shortcut method of estimating key input-output model parameters should prove invaluable in saving limited resources and allowing the input-output model to be applied when hitherto it was considered too costly. This point would apply particularly to small regions where the need for information relating to interindustry linkages is not matched by an ability to collect the data necessary for conventional input-output analysis. This paper reviews recent relevant work on the development of shortcut methods for computing final-demand multipliers, and then proposes a new shortcut method which is felt to be particularly applicable to small regions. A familiarity with input-output analysis is assumed throughout.

Recent literature

The recent attempts to develop shortcut methods for calculating final-demand multipliers are those of Bromley (1972) and Salcedo (1972), and an evaluation of their methods (notably that of Salcedo) is considered in Nelson and Perrin (1978). An alternative approach to the problem is provided in Drake (1976) and Burford and Katz (1977). These papers are reviewed briefly to provide a context for the present work.

Bromley's approach involves the computation of an "index of internal purchases" which relates the proportion of the internal purchases of each sector to its total purchases. By means of matrix algebra he develops a theoretical linkage between his index of internal purchases and the computational procedures used to derive final-demand multipliers. He substantiates this linkage empirically by means of tests upon eight published input-output studies. These tests use regression analysis to show that there is a very close relationship between the proportion of internal purchases and final-demand multipliers.

However, Bromley's method has one serious weakness. By using the proportion of internal purchases as a basis, it only produces a ranking of sectors according to their final-demand multipliers. No multiplier estimates are derived that mean anything in physical terms. Rather the method allows us to state only that sector A has a bigger multiplier than sector B. Therefore, although Bromley's method is a good starting point in the search for a shortcut method for multiplier estimation, it is considered that it does not generate sufficient useful information and thus go far enough to be generally acceptable.

Salcedo goes further than Bromley by attempting to estimate the actual multipliers associated with any sector of a given economy. Salcedo achieves his aim by deriving a linear relationship between the proportion of the total purchases of each sector which 'leak' out of the endogenous sectors through final payments (or the ratio of final payments to total inputs). He postulates that a straight line can be drawn showing the relationship between final demand multipliers and the ratio of final payments to total inputs. He states that one end point of such a line is constant for any economy, and this end point has fixed coordinates of 1·0, 1·0. At this point the total purchases of a sector are obtained from the exogenous sectors of the economy, that is, final payments. Since such a sector makes no internal purchases, leakage is 100%. In such a sector there would be no multiplier effects on the rest of the economy, and hence the final demand multiplier of the sector would be 1·0.

Salcedo goes on to say that at the other end point it is necessary to estimate the final-demand multiplier for a sector which makes all (100%) of its purchases from other internal sectors, which causes its ratio of final payments to total inputs to be zero. In this situation he suggests that the multiplier is a reflection of the operation of the entire economy. Therefore he calculated the multiplier as the inverse of the proportion of leakage from the entire economy through the processing sectors to the total inputs of processing sectors plus the total final demand of the economy. Salcedo then joined the two sets of coordinates thus establishing his line of inverse relationship between final-demand multipliers and the ratio of final payments to total inputs.

Nelson and Perrin (1978) used results from the Texas and the US Department of Commerce (1974) input-output analyses to evaluate the accuracy of results obtained from both Salcedo's and Bromley's methods, particularly those of the former. They concluded that Salcedo's method can yield "final demand multipliers which are in quite close agreement with those derived by traditional input-output analyses" (Nelson and Perrin, 1978, page 91). However, they tend to overlook and underplay serious problems associated with Salcedo's method. Although we agree with the view of Nelson and Perrin that Salcedo's method requires "far fewer data than a traditional input-output model" (Nelson and Perrin, 1978, page 82) it still demands a substantial amount of data, since unlike the Bromley method, which only uses proportions, Salcedo's technique requires exact values for both total inputs and total final demand.

More recently Drake (1976) and Burford and Katz (1977) have made contributions to the shortcut multiplier literature. They each develop formulae for output multipliers by assuming that the inverse of $(\mathbf{I}-\mathbf{A})$ can be viewed as a power series of the matrix $\mathbf{A}$. Although their work has been a valuable addition to the literature, both contributions suffer from major weaknesses.

First, Drake's dependence on the national table to estimate direct coefficients for any industry under consideration seriously affects the reliability of his results. The multipliers he estimates through the use of his shortcut formula differ substantially from those taken from survey-based tables. For example the ratio of estimated to survey values ranged from 0·63 to 1·60.

Second, although Burford and Katz developed a method that did not rely on the national table, their work is seriously flawed by their incorrect definition of the total output multiplier. This criticism is noted also by Jensen (1979, page 98).

A new shortcut method

The authors propose that a shortcut method is available that avoids the pitfalls of the above methods. It is based on first taking the mathematical formula for final demand multipliers (where the terms of this formula are elements of the trade coefficient matrix) and then removing terms which are considered to have insignificant impact on the magnitude of the multiplier. The remaining terms constitute the shortcut formula for deriving final demand multipliers.

In conventional input–output analysis it is well-known that the final demand multiplier for the jth sector is formed by summing the elements in the jth column of the $(\mathbf{I}-\mathbf{A})^{-1}$ matrix where $\mathbf{I}$ is the identity matrix and $\mathbf{A}$ is the trade-coefficient matrix within sectors. By using this well established expression, the derivation of the shortcut formula can be demonstrated. In order to make the calculation less cumbersome an $\mathbf{A}$ matrix with only four sectors will be used.

Assume the trade coefficient matrix is

$$\begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \\ a_{31} & a_{32} & a_{33} & a_{34} \\ a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix} .$$

Therefore the $(\mathbf{I}-\mathbf{A})$ matrix is

$$\begin{bmatrix} 1-a_{11} & -a_{12} & -a_{13} & -a_{14} \\ -a_{21} & 1-a_{22} & -a_{23} & -a_{24} \\ -a_{31} & -a_{32} & 1-a_{33} & -a_{34} \\ -a_{41} & -a_{42} & -a_{43} & 1-a_{44} \end{bmatrix} .$$

From this it follows that the sum of the first column of the inverted $(\mathbf{I}-\mathbf{A})$ matrix or the output multiplier (m_1) is given by

$$\begin{aligned} m_1 = \frac{1}{\lambda}\{ & [(1-a_{22})(1-a_{33})(1-a_{44}) - a_{32}(a_{43}a_{24}+a_{23}-a_{23}a_{44}) \\ & -(1-a_{22})(a_{43}a_{34}) - a_{42}(a_{23}a_{34}+a_{24}-a_{33}a_{24})] \\ & -[-a_{21}(-a_{44}-a_{33}+a_{33}a_{44}-a_{43}a_{34}) - a_{31}(a_{43}a_{24}+a_{23}-a_{23}a_{44}) \\ & -a_{41}(a_{24}-a_{33}a_{24}+a_{23}a_{24}) - a_{21}] \\ & +[-a_{21}(-a_{32}+a_{32}a_{44}-a_{42}a_{34}) - a_{31}(a_{42}a_{24}+a_{44}+a_{22}-a_{22}a_{44}) \\ & -a_{41}(-a_{34}+a_{22}a_{34}-a_{32}a_{24}) + a_{31}] \\ & -[-a_{21}(a_{32}a_{43}+a_{42}-a_{42}a_{33}) - a_{31}(a_{42}a_{23}+a_{43}-a_{43}a_{22}) \\ & -a_{41}(-a_{32}a_{23}-a_{33}-a_{22}+a_{33}a_{22}) - a_{41}]\} , \end{aligned} \tag{1}$$

where λ is equal to the determinant of $(\mathbf{I}-\mathbf{A})$.

This expression can be reduced by size by using a reduction technique that is commonly employed in applied mathematics. The main principle of this technique is that the removal of small terms from an expression will not significantly affect the magnitude of the result.

Looking again at equation (1), obviously the largest terms are the $(1-a_{ii})$ terms, and these can be called the first-order terms. The a_{ij} terms are going to be smaller than the first-order terms[(1)], and these can be called second-order terms. The third-order terms are the $a_{ij}a_{ij}$ terms and so on. Further, multiplying any order term by a first-order term leaves its order unchanged.

It is possible to simplify equation (1) by removing all the third-order and larger-order terms and by replacing them with a general error term. Hence equation (1) can be rewritten as

$$m_1 = \frac{1}{\lambda}[(1-a_{22})(1-a_{33})(1-a_{44})+a_{21}+a_{31}+a_{41}]+E_1 \,. \tag{2}$$

where E_1 is an error term.

Now the sum of intermediate inputs for sector 1 (u_1) can be written as

$$u_1 = a_{11}+a_{21}+a_{31}+a_{41} \,, \tag{3}$$

that is,

$$u_1 - a_{11} = a_{21}+a_{31}+a_{41} \,. \tag{4}$$

Substitution of equation (4) into equation (2) gives

$$m_1 = \frac{1}{\lambda}[(1-a_{22})(1-a_{33})(1-a_{44})+u_1-a_{11}]+E_1 \,. \tag{5}$$

By means of a similar reduction method the determinant simplifies to

$$\lambda = (1-a_{11})(1-a_{22})(1-a_{33})(1-a_{44})+E_2 \,, \tag{6}$$

where E_2 is the error associated with the removal of the third-order terms and above.

Therefore equation (5) can be rewritten as

$$m_1 = \frac{(1-a_{22})(1-a_{33})(1-a_{44})+u_1-a_{11}}{(1-a_{11})(1-a_{22})(1-a_{33})(1-a_{44})}+E_3 \,, \tag{7}$$

or

$$m_1 = \frac{1}{1-a_{11}}\left[1+\frac{u_1-a_{11}}{(1-a_{22})(1-a_{33})(1-a_{44})}\right]+E_3 \,, \tag{8}$$

where E_3 is the error associated with the removal of the second-order and above terms from equation (1).

The above formula can be generalised so that the multiplier for sector i (m_i) for trade-coefficient matrix A of n sectors is

$$m_i = \frac{1}{1-a_{ii}}\left[1+(u_i-a_{ii}\Big/\prod_{\substack{j=1\\j\neq i}}^{n}(1-a_{jj})\right]+E \,. \tag{9}$$

The fundamental significance of expressing the multiplier in the above form is that only two pieces of information are required of each sector for substitution into equation (9). These are the proportion of inputs that come from within the regions, and second the proportion of local inputs that come from the same sector.

The size of the error term

The accuracy of the formula in equation (9) obviously depends on the size of the error term. An estimate of its likely magnitude can be made after a closer examination of equation (1).

[(1)] Obviously they will not be smaller if a_{ij} is greater than 0·5, but this would be extremely unlikely in a regional table.

If it is assumed that pairs of fourth-order terms that have opposite signs cancel each other out, then E_1 (that is, the terms that have been removed by the reduction process) can be written as

$$E_1 = \frac{1}{\lambda}\{[-A_3-(A_3-A_4)-A_3]-[-a_{21}(-2A_2)-a_{31}(A_2)-a_{41}(A_2)] + [-a_{21}(-A_2)-a_{31}(2A_2)-a_{41}(-A_2)]-[-a_{21}(A_2)-a_{31}(A_2)-a_{41}(-2A_2)]\}\,, \tag{10}$$

where A_1, A_2, and A_3 are second-order, third-order, and fourth-order terms, respectively.

If it is further assumed that third-order terms with opposite signs cancel each other out, then equation (10) can be rewritten as

$$E_1 = \frac{1}{\lambda}[-2A_3-(A_3-A_4)]\,. \tag{11}$$

This expression is obviously going to be fairly small. Conversely, it can be seen from equation (10) that the E_1 term for any sector has the potential for being quite large if the intermediate input coefficients for that sector vary significantly in magnitude.

E_2, or the error associated with the determinant, is much less of a problem for two reasons. First, a large proportion of the error terms are third-order terms and hence have tiny values, and second the absolute number of error terms associated with E_2 is considerably less than with E_1. Therefore, E_2 is only likely to become large when a large number of sectors is used.

Therefore, from the preceding discussion it can be concluded that E_3 will be large when either the model contains a large number of sectors and/or the terms of the trade coefficient matrix vary significantly in magnitude. Following on from this latter condition, it is obvious that if the trade coefficients are large then the potential for error is great, because a small percentage variation in magnitude will lead to a large absolute difference. Hence, E_3 is likely to be small in the case of small regions where the trade coefficients and the number of identifiable sectors would both be small, though it is appreciated that E_3 may be large relative to the magnitude of the multiplier which will also be small.

Taking these statements of error terms into consideration it is therefore suggested that for small regions a shortcut formula for estimating final-demand multipliers is given by the formula:

$$m_i = \frac{1}{1-a_{ii}}\left[1+(u_i-a_{ii})\Big/\prod_{\substack{j=1\\ j\neq i}}^{n}(1-a_{jj})\right]\,. \tag{12}$$

Empirical tests

The following section uses a number of Australian input–output studies and also a British example to empirically ascertain the difference between multipliers estimated by equation (12), and those derived from a full input–output table. In so doing the reliability of the shortcut method can be tested. The four input–output studies referred to are

1. *Central Queensland* This input–output study undertaken by Jensen (1976) encompassed three Queensland statistical divisions in central Queensland. The geographical area under study is vast, and stretches from Rockhampton on the Pacific coast to the Northern Territory border. Population density is low with the total population of the study area being 135000. It is predominantly a rural region, specialising in sheep and cattle, with an active (and growing) coal mining sector. A large proportion of manufactured goods have to be imported. The central Queensland model contains twenty-six sectors.

2. *Muswellbrook* McCalden's (1969) study of Muswellbrook examines the input-output relationships of this medium size town in the upper Hunter Valley in New South Wales. The population of the study area was approximately 6500. Muswellbrook acts as a service centre for the surrounding rural region which includes coal mining and wine growing interests in addition to traditional rural activities. Many of the coal miners who work in nearby mines live in Muswellbrook. The Muswellbrook model contains seventeen sectors.
3. *Cooroy* The Cooroy study (Dawes et al, 1974) examines the input-output relationships of a small rural town in Queensland. Cooroy which showed a population of 1130 in 1971 is located 145 kilometres north of Brisbane. The population has remained more or less static in number for many years. As the authors state (Dawes et al, 1974, pages 142-143) "the township exhibits the normal trading pattern of small Australian rural towns—almost all the manufactured commodities are imported to the town and the local primary produce constitutes most of the exports. Only lower order goods and services are provided locally; the remainder are imported." The study used intersectoral flows analysis to develop a transaction table, which contained just twelve sectors.
4. *Peterborough* The study referred to is that of Morrison (1973). Peterborough is a medium sized town in the East Midlands of the UK. The town acts as a regional centre for a predominantly rural area, but also possesses a substantial manufacturing sector. In 1967 (when the field work was carried out) it had a population of 82000.

For each of the four studies, estimates of final-demand multipliers for each sector were calculated by means of the formula developed in equation (12). The resulting multipliers were then compared to the output multipliers that were derived from summing the columns of the inverted trade-coefficients matrix. The results of this exercise appear in table 1.

The results indicate that the shortcut method is a good predictor of the 'correct' multiplier values, with the error in all cases being kept within reasonable bounds. The larger error associated with the Muswellbrook study occurred because of the greater variation in the trade coefficients of particular sectors. The very small error associated with the Cooroy study highlights the extreme accuracy of the proposed method whenever the trade coefficients are small[2]. The maximum error, in all cases, was associated with the sector with the largest sum of intermediate inputs.

Table 1. Differences between shortcut estimates and the 'correct' multiplier.

	Mean percentage error [a] between shortcut estimate and 'correct' multiplier	Standard deviation of difference	Maximum error (%)	Minimum error (%)
Central Queensland	2·7	1·9	8·1	0·1
Muswellbrook	3·3	3·0	11·2	0·6
Cooroy	0·4	0·3	1·0	0·01
Peterborough	0·2	0·6	3·5	0·0002

[a] Percentage error $= \left(1 - \dfrac{\text{shortcut estimate}}{\text{correct multiplier}}\right) \times 100.$

Summary and conclusions

This paper has considered deficiencies in previously developed shortcut means of estimating final-demand multipliers and develops an alternative procedure by simplifying the mathematical formula for final-demand multipliers. It is held that the procedure

(2) The largest trade coefficient in the Cooroy study was 0·135 and many of the entries were zero.

outlined above is most appropriate when investigating interindustry relationships of small regions. Empirical tests in Australia validate this statement.

The greatest advantage of the shortcut method presented in this paper is its value as a resource saving alternative to traditional input-output final-demand multipliers. Data requirements are minimised. The usual lengthy questionnaire needed for an input-output study can be summarised to a request for just two essential pieces of information which can be substituted into equation (12), namely the proportion of local inputs that come from the same sector and the proportion of inputs that come from within the region under study. These data can be acquired from a sample mail survey which requests firms to estimate these critical values. This procedure has recently been undertaken by the authors in developing an input-output table for the Hunter Region of New South Wales for the New South Wales State Government's Planning and Environment Commission.

It is conceded that the method outlined here provides reliable output multiplier estimates only for small regions. Although this limits the usefulness of the method, it must be remembered and appreciated that small regions are often those regions that are unable to find the resources required to mount a full-scale input-output analysis, but nevertheless are very interested in multiplier estimates. It is also impossible to state precisely when the method becomes inaccurate, however, sensitivity tests suggest that to make sure that the error is below 15% the method should only be used when the determinant estimate is above 0·5 and/or the proportion of intermediate inputs is less than 0·6. If practitioners work within these bounds, they can be confident of obtaining good if not excellent multiplier estimates for a minimum outlay of resources. The method is therefore seen as providing a much needed short circuit in local multiplier studies, and implies an improved allocation of research resources into our understanding of small regional economies.

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THE CUMULATIVE AND DISAGGREGATED IMPACTS OF NEW ALUMINIUM SMELTING CAPACITY IN THE HUNTER VALLEY AN INPUT-OUTPUT ANALYSIS

by

*P . J . Phibbs**

1.0 INTRODUCTION

Three proposals currently exist for expanding aluminium smelting capacity in the Hunter Region of N.S.W. The Tomago Aluminium Company has recently received government approval for a 220,000 tonne smelter at Tomago. Hunter Valley Aluminium Pty. Ltd., is presently seeking approval to build a 236,000 tonne plant at Lochinvar, and Alcan aims to increase the capacity of its Kurri Kurri Plant by 45,000 tonnes by 1984. If all these developments go ahead, the Hunter Region will become the most concentrated region of aluminium production in the world.

This expansion of smelting capacity is a subject that has generated a great deal of controversy at a regional, state, and national level. Whilst not wanting to enter the debate about the economic costs and benefits of the proposed developments, one of the valid criticisms of the anti-smelter(s) lobby is that at no stage has there been an attempt to assess the cumulative economic impacts of the proposed developments, but instead, through the E.I.S. process, individual impact assessment of each development has taken place. Furthermore, it has also been argued that these individual impact assessments have been of a fairly simplistic nature, examining only the aggregate impact of each development.

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This paper attempts to overcome these two deficiencies by assessing the cumulative employment[1] impact of the three smelter proposals: firstly, in aggregate terms; secondly, by industry sector; and lastly, by the age, sex, and level of skill of the impacted workforce.

2.0 METHODOLOGY

The basic methodological framework used in this paper is input-output analysis. This approach, now widely used in economic impact analysis, involved the addition of an extra row and column, representing the trade coefficients of the aluminium smelting sector, to the H.V.R.F. input-output table for the Hunter (Garlick, 1979). The augmented input-output table was then inverted, and the employment multipliers calculated in the traditional manner of input-output analysis. A diagrammatical summary of the methodology, appears in Figure 1.

2.1 Estimating the row and column coefficients for the smelting sector.

The data originally used to construct the input coefficients for an aluminium smelter in the Hunter, were those originally obtained from Alumax in late 1979. These data were used by the authors to generate the multipliers presented in the Alumax E.I.S. and subsequently reproduced in the Tomago and Alcan E.I.S.'s. However, given the recent revelation of the electricity price for the Tomago smelter, and likely dissimilarities in the input coefficients of the different proposals, a new set of input coefficients was estimated. This task was accomplished by estimating the raw material needs of the smelters, on the basis of data published in the respective E.I.S.'s, and then obtaining likely prices of these raw material inputs through contacting relevant local suppliers.

In order to estimate the smelters' output coefficients, it was assumed that all production from the smelters would be exported from the Hunter Region. Whilst this may not turn out to be the case, especially given the growing role of BHP at Lochinvar, it was impossible to accurately assess the level of production to be consumed and/or processed within the region. In general terms, if a substantial

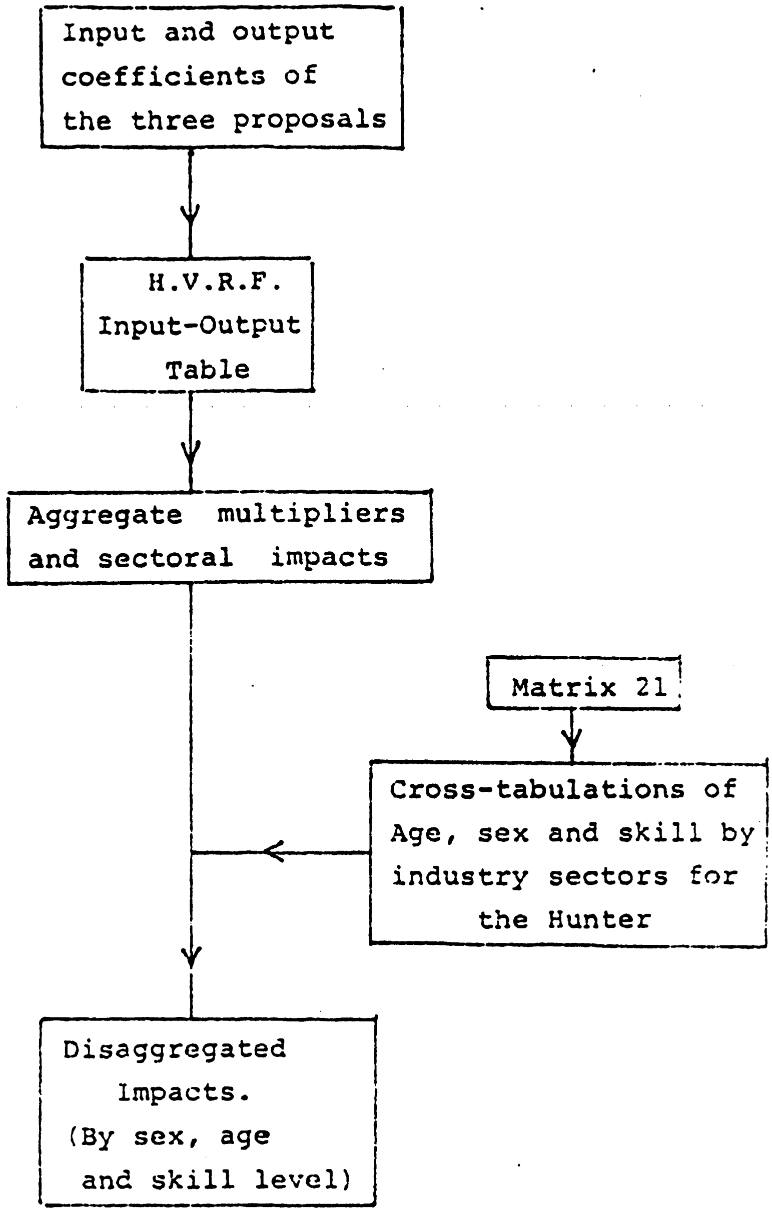

Figure 1 METHODOLOGICAL OUTLINE

proportion of the output from the smelters is consumed and/or processed within the region, the employment impacts identified in this paper would certainly underestimate the true situation.

2.2 Estimating the employment coefficients to calculate the disaggregated multipliers

In order to assess the flow-on employment impacts of the smelters by age, sex and skill level, it was first necessary to estimate sectoral employment coefficients, for each age, sex and skill category. This task was accomplished using a 1976 Census Matrix Tape (No. 21) which generated cross-tabulations of age, sex and skill level by industry sector, for the Hunter Statistical Division. Five age, and nine skill categories were used, the skill categories being based on the occupational grouping system devised by the IMPACT group (see Craigie, 1979). The nine skill categories are listed in Table 1. The number of people employed in each particular age, sex and skill category was then used to calculate employment coefficients in the traditional manner (i.e. employment divided by output).

TABLE 1
THE SKILL CATEGORIES

Name	Abbreviation used in Figures 2 to 7
1. Professional White Collar	PWC
2. Skilled White Collar	SWC
3. Semi and Unskilled White Collar	SEUWC
4. Skilled Blue Collar (Metal and Electrical)	SBCME
5. Skilled Blue Collar (Building)	SBCB
6. Skilled Blue Collar (other)	SBCO
7. Semi and Unskilled Blue Collar	SEUBC
8. Rural Workers	RW
9. Other (including Armed Services)	O

In order to disaggregate the direct employment impacts of the smelter, a similar procedure was followed. The matrix tape was used to generate cross-tabulations of age, sex and skill level for the smelting sector as it currently operates in the region. The proportions identified by this operation, were then applied to the aggregate direct employment requirements of the development proposals, in order to generate the disaggregated direct employment impacts.

Before outlining the result, it should be noted that this attempt to disaggregate regional employment impacts is an innovative approach. However, the results generated should only be regarded as indications of the likely actual situation, and for this reason, rounded percentage results are presented, rather than the actual number of jobs. This is because problems, additional to those that normally occur with input-output multipliers, arise when the multipliers are disaggregated. These additional problems occur for two reasons. Firstly, as aggregate employment coefficients are increasingly disaggregated, the traditional input-output weakness, concerning the use of average rather than marginal coefficients, is exacerbated. Secondly, the disaggregated employment coefficients are based on current (or as current as data availability permit) profiles of the workforce. However, as attitudes change to such things as female participation in the workforce, female participation rates may change. If this occurs, the accuracy of the disaggregated impact multipliers will be compromised.

3.0 THE RESULTS

3.1 Aggregate Total Impacts

The aggregate employment multipliers for the smelter proposals are shown in Table 2. It must be emphasized that the use of the multipliers is subject to the assumption of fixed coefficients of production. That is the production function is assumed to be linear, implying constant returns to scale, no substitution between inputs, no price reactions to output changes and no investment capacity or labour supply constraints.

It is useful to note that the multipliers in Table 2 are lower than the multipliers published in the E.I.S.'s for three reasons. Firstly, as mentioned earlier, different input coefficients were used for the smelting sector. Also, a lower electricity employment coefficient was used, in order to reflect more accurately the employment

TABLE 2 - EMPLOYMENT MULTIPLIERS - ALUMINIUM SMELTING - HUNTER REGION

(jobs for $m of sales to final demand)

Direct Employment Impact[a]	Production Induced Flow-Ons[b]	Consumption Induced Flow-Ons[c]	Total Flow-Ons[d]	Total Employment Impact[e]	Type I Multiplier[f]	Type II Multiplier[g]
4.2936	1.4645	1.9768	3.4413	7.7349	1.3411	1.8015

(a) The employment provided directly at the smelters.

(b) The extra employment generated by the first and subsequent round effects, as production increases in the region in order to provide the necessary inputs into the smelting process.

(c) The extra employment generated as a result of increased private consumption expenditure in the region.

(d) The sum of (b) and (c).

(e) The sum of (a) and (d), i.e. the direct employment impact, plus the total flow-ons.

(f) [(a) + (b)]/(a), i.e. only production induced flow-ons are considered.

(g) (e)/(a), i.e. total flow-ons are considered.

implication of the combined electricity consumption of the smelters. Secondly, when all three smelter proposals are considered, the employment coefficient is larger than in the Alumax case. Finally, the H.V.R.F. input-output table was modified to rectify an error in its consumption coefficients.

Applying the multipliers of Table 2 to the direct employment impact of the proposals of 1945 jobs, indicates that the production induced flow-ons for the smelters will equal 663 jobs, and the consumption induced flow-ons will generate an additional 896 jobs. Hence, the total flow-on impact is equal to 1559 jobs, and the total employment impact is equal to 3504 jobs.

In recent years, there has been considerable debate about the comparative reliability of Type I and Type II multiplier estimates. Some regional scientists consider that the average consumption coefficients usually used in input-output analysis, lead to the overestimation of consumption induced flow-ons. They argue, that this factor, coupled with the inherent tendency of input-output tables to overestimate impacts because of the assumption of fixed coefficients, means that it is wiser to use Type I multipliers to represent employment impacts. This stance was adopted by Mandeville and Jensen (1978) in their work on the impact of the Gladstone smelter. They argued that Type I employment estimates provided a more reliable indication of the order of magnitude of expected employment impacts, and that Type II multipliers should be interpreted as the absolute maximum effects. Such an interpretation was also adopted in the Alumax E.I.S.

However, it must be remembered that in some situations, input-output tables could underestimate employment impacts. For example, in the case of the smelter proposals, business could be so buoyed up by the developments, that a triggering of other developments might take place, above and beyond those predicted by the static input-output model.

Unfortunately, there is little or no empirical work available to resolve this particular debate. Nevertheless, one would suspect that given the large amount of publicity given to the proposals and current national figures for projected new business investment, the impact of the proposals may be closer to the Type II estimates, rather than the Type I estimates, in this case.

3.2 Sectoral Impacts

In Table 3, the flow-on impacts of the proposals are broken down by the sector. Both the production induced and total flow-ons are listed.

The table shows, for example, that the production flow-ons are concentrated in three sectors, namely the mining, electricity and transport sectors. This situation reflects the importance of electricity as an input into the smelting process, the large amounts of coal needed to produce this electricity and the important role of the transport sector in supplying the raw materials to the smelters.

However, as may be expected, when consumption-induced flow-ons are also included, the domination of these three sectors is broken. In this case, flow-ons are spread more evenly throughout the regional economy, with the major impacts being felt in the wholesaling and retailing sector, the transport sector, the mining sector, the finance, business and professional services sector and the electricity sector.

3.3 Flow-on Employment Impacts by Labour Type

The employment impacts, by labour type, for both production induced flow-ons, and total flow-ons, are shown in Figures 2 to 4. Also shown in these figures, are the current regional employment distributions for age, sex and skill level.

3.3.1 Flow on Employment Impacts by Age (Figure 2)

The slightly younger age profile of the total flow-on impacts, reflects the greater proportion of young people in the wholesaling and retailing sector. In comparison with the age distribution of the regional workforce, the production-induced flow-ons favour older age categories, whilst the total flow-on age distribution closely resembles the age structure of the present workforce.

TABLE 3 - SECTORAL EMPLOYMENT IMPACTS OF ALUMINIUM SMELTING

THE HUNTER REGION

	Sector	% of Production Flow-ons attributable to the Sector	% of Total Flow-ons (i.e. Production & Consumption) attributable to the Sector
1.	Rural	0.22	4.68
2.	Mining	24.62	10.74
3.	Food, Beverages and Tobacco	0.11	5.01
4.	Textiles, Clothing and Footwear	0.04	1.60
5.	Basic Metal	1.59	0.85
6.	Fabricated Metal Products and Transport Equipment	5.07	2.57
7.	Chemicals, Petroleum and Coal Products	3.14	1.40
8.	Glass, Clay and other non-metal Mineral Products	4.36	2.90
9.	Wood, Wood Products and Furniture	0.97	0.91
10.	Paper and Paper Products, Printing	0.58	0.69
11.	Other Manufacturing	2.23	1.33
12.	Electricity, Gas and Water	21.22	9.39
13.	Building and Construction	2.76	7.03
14.	Wholesale and Retail	3.78	16.28
15.	Transport, Storage and Communications	16.48	11.02
16.	Finance, Business and Professional Services	6.77	9.80
17.	Public Authority and Defence	4.82	5.58
18.	Community and Other Services	0.74	8.22
		100.00	100.00

3.3.2 Flow-on Employment Impacts by Sex (Figure 3)

A high proportion of the production induced flow-ons will accrue to the male sector of the workforce (over 85%). However, when the total flow-ons are considered, the female section of the labour force fares better, attracting just over 25% of the employment flow-ons. In comparison, males comprise about 68% of the regional workforce at present.

3.3.3 Flow-on Employment Impacts by Skill Level (Figure 4)

A high proportion of the production induced flow-ons (just over 45%) will accrue to semi and unskilled blue collar workers. Other major skill categories that attract a significant proportion of the flow-ons are skilled blue collar (metal/electrical) workers (21%), and semi and unskilled white collar workers (18%).

When the total employment flow-ons are considered, more of the impact is felt by white collar workers, due to the increased prominence of the retailing and wholesaling sector. The major skill categories impacted include semi and unskilled blue collar workers (35%), semi and unskilled white collar workers (25%), and skilled blue collar (metal/electrical) workers (13%).

In comparison to the skill profile of the current regional workforce, the skill distribution of the production induced flow-ons favours blue collar workers, with notably more emphasis on the semi and unskilled blue collar category (45% as opposed to 32%). When the total flow-ons are considered the distribution more closely approximates the distribution displayed by the current workforce. The major differences are that the total flow-on percentages are below the current skill distribution percentages for skilled and professional white collar workers, but greater than the current figure for semi and unskilled blue collar workers.

3.4 Total Employment Impacts

Thus far, only the total flow-on impacts have been disaggregated. This section presents disaggregated results for the total employment impacts of the proposals - that is, the total flow-on impacts plus the direct impacts.

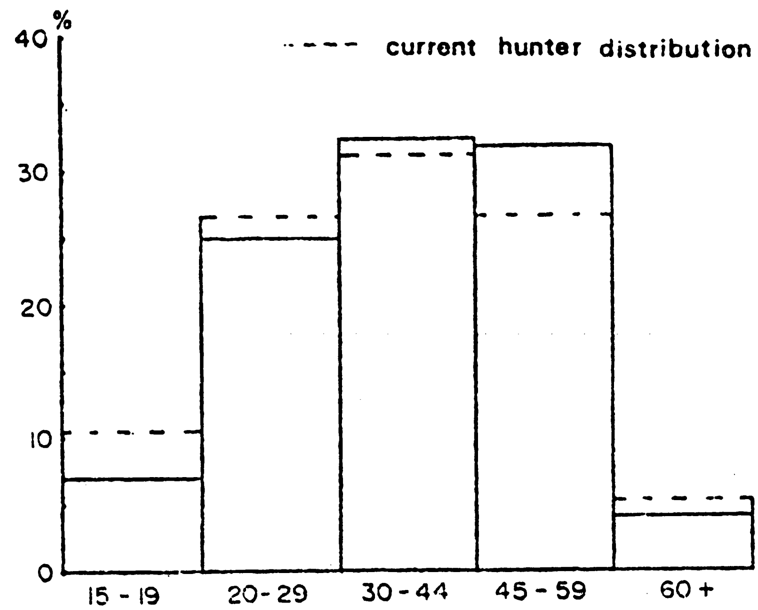

FIGURE 2a PROD'N INDUCED FLOW-ON IMPACTS BY AGE

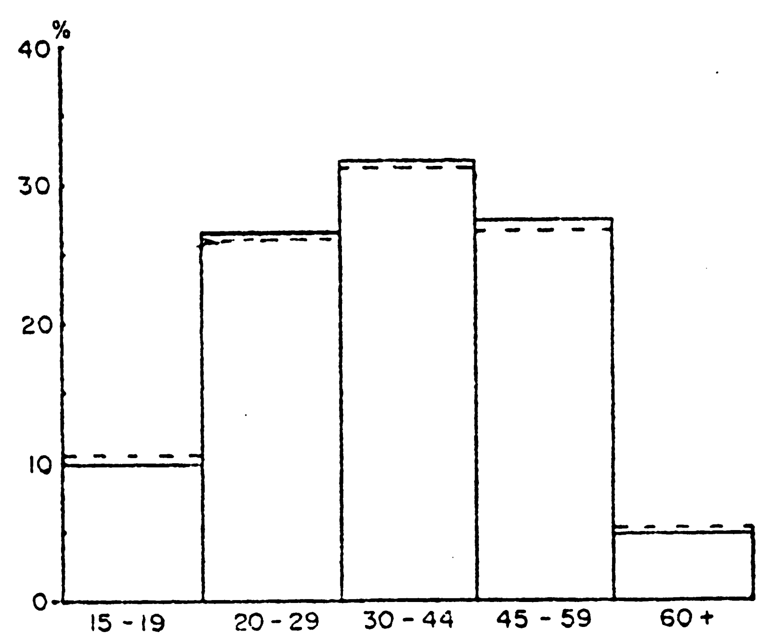

FIGURE 2b TOTAL FLOW-ON IMPACTS BY AGE

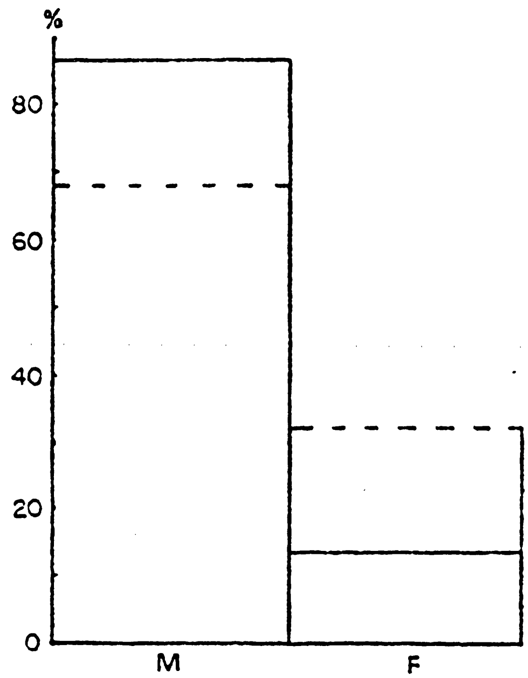

FIGURE 3a PROD'N INDUCED FLOW-ON IMPACTS BY SEX

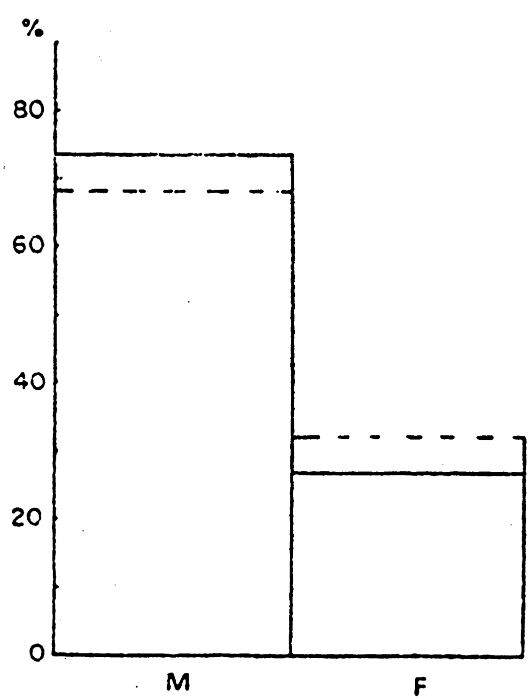

FIGURE 3b TOTAL FLOW-ON IMPACTS BY SEX

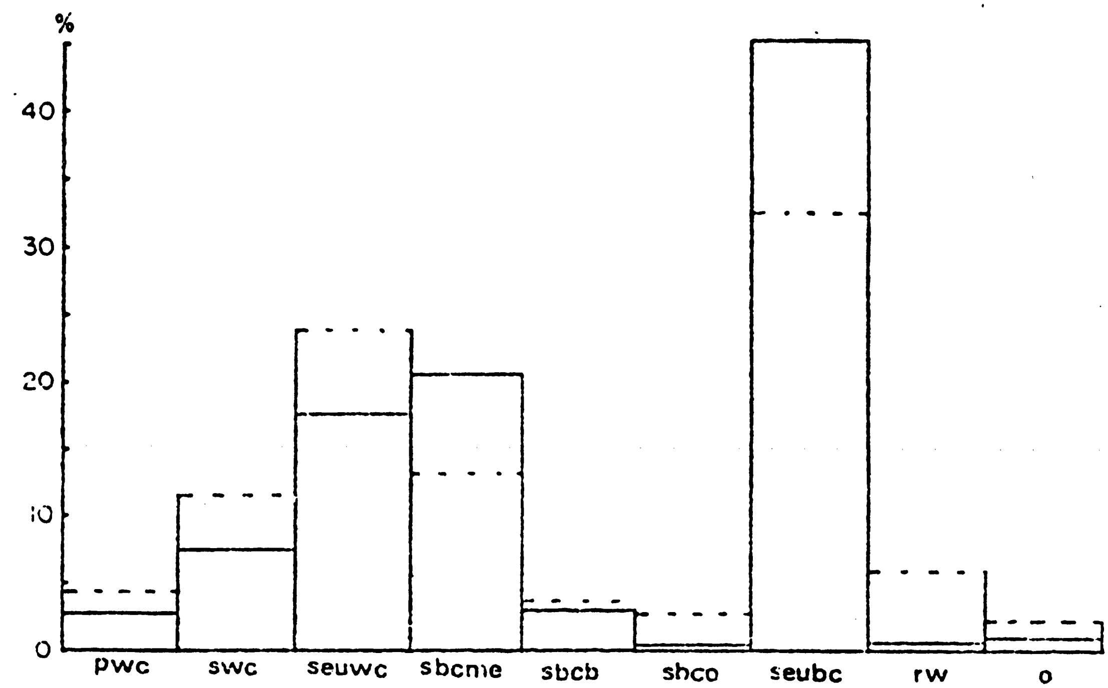

FIGURE 4a PROD'N INDUCED FLOW-ON IMPACTS BY SKILL LEVEL

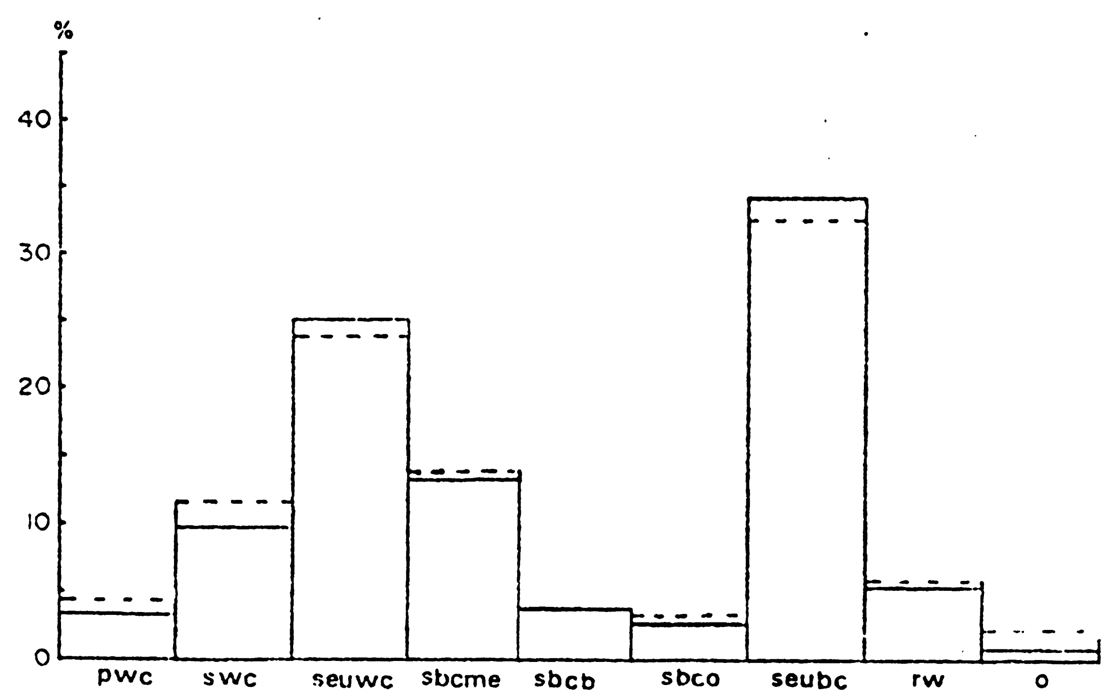

FIGURE 4b TOTAL FLOW-ON IMPACTS BY SKILL LEVEL

In order to disaggregate the total employment impacts, the following procedure was undertaken. On the basis of current age, sex and skill distributions in the aluminium smelting sector in the Hunter, the 1945 direct jobs generated by the three smelters, were assigned to age, sex and skill categories, and then these direct impacts were added to the flow-on impacts discussed in the previous section. The results of this procedure are shown in Figures 5 to 7.

3.4.1 Total Employment Impact by Age (Figure 5)

In comparison with the age distribution of the current regional workforce, the age distribution profile of the total employment impact displays a smaller percentage of workers in the youngest and oldest categories, but a much larger percentage of workers in the middle age category.

3.4.2 Total Employment Impacts by Sex (Figure 6)

The total employment impact of the smelters is characterised by the <u>low percentage of jobs that will be generated in the female sector of the workforce</u>. About 84% of the jobs generated by the smelter proposals will be occupied by males, in contrast with the present figure in the region of 68 percent.

3.4.3 Total Employment Impact by Skill Levels (Figure 7)

The total employment impact's skill profile shows, that in contrast to the present regional skill distribution of the workforce, the proposals will generate a greater proportion of blue collar jobs. More particularly, the vast majority of these blue collar jobs will be in the semi and unskilled blue collar category. In total, about 52 percent of the total jobs generated will be in the semi and unskilled blue collar category, in contrast to the present regional figure of 32 percent. Furthermore, only 15 percent of the jobs generated will be skilled blue collar jobs, in contrast to the present regional figure of 20 percent.

4.0 <u>CONCLUSIONS</u>

This paper has considered the cumulative employment impact of the

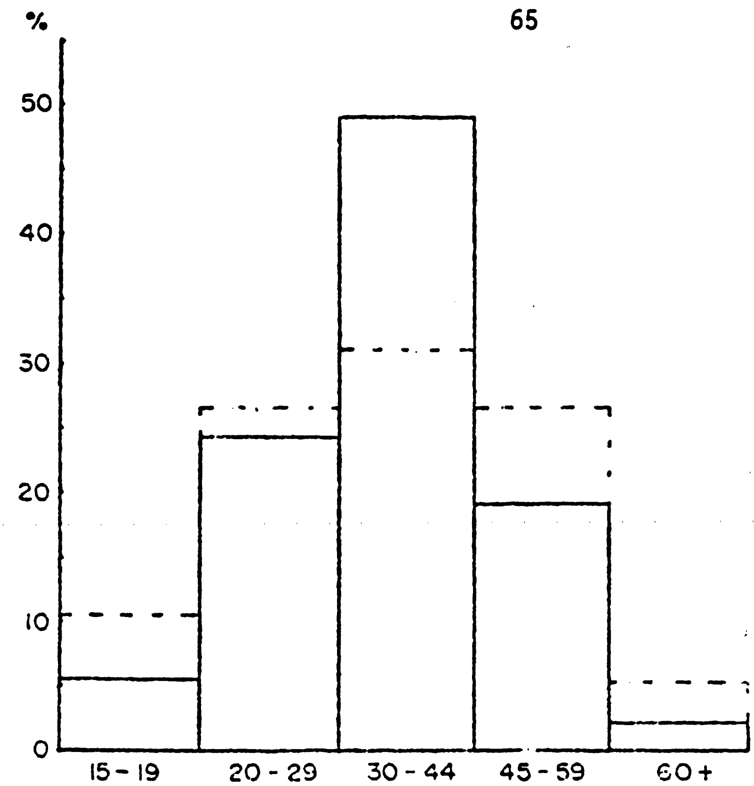

FIGURE 5 TOTAL IMPACT BY AGE

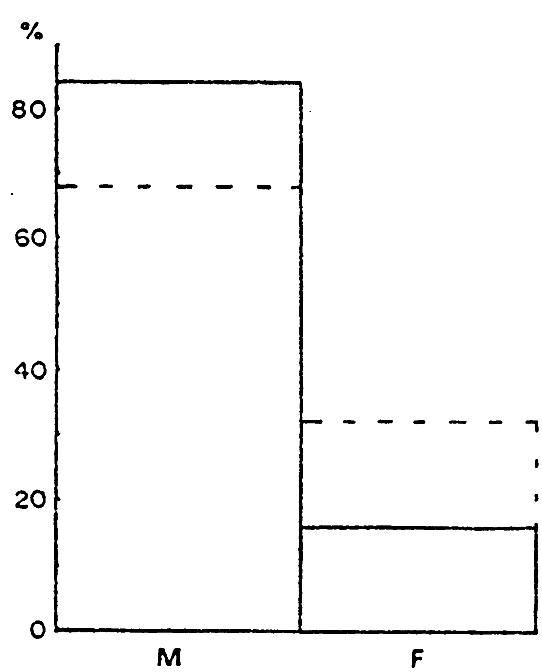

FIGURE 6 TOTAL IMPACT BY SEX

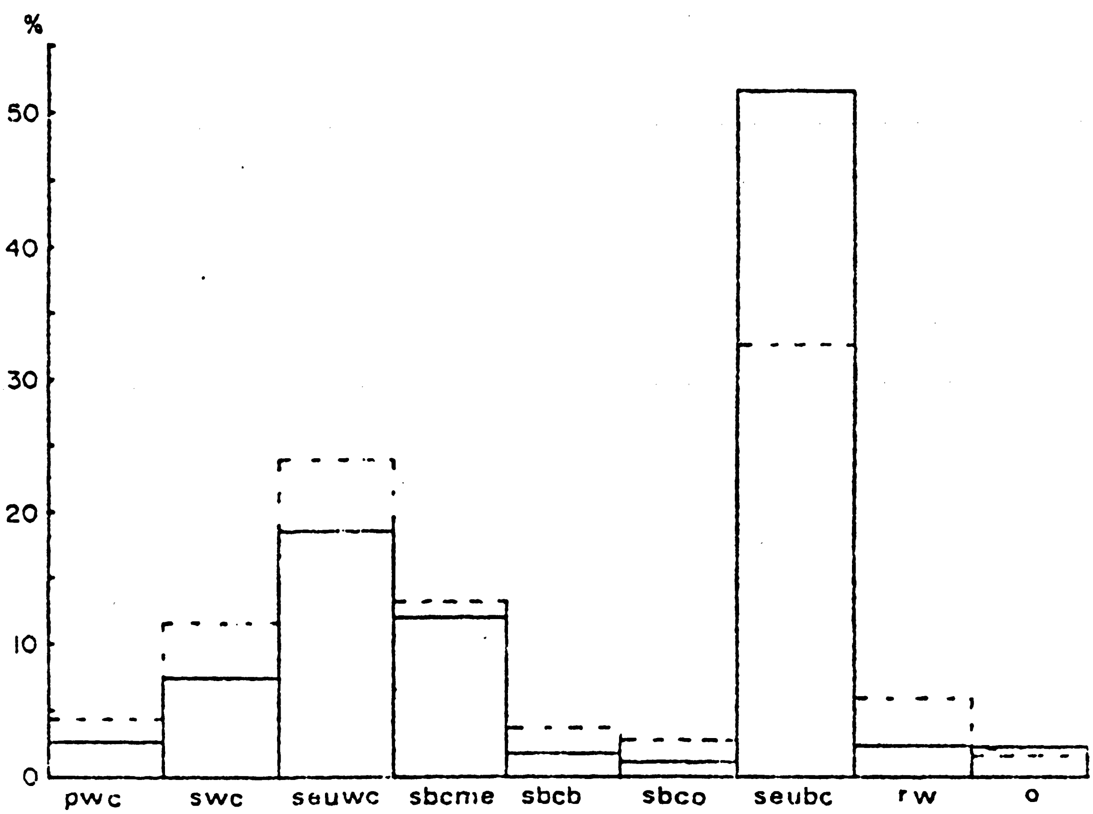

FIGURE 7 TOTAL IMPACT BY SKILL LEVEL

Hunter region's aluminium smelting proposals, in both an aggregate and disaggregated manner. Whilst in comparison with aggregate multipliers there are limitations to the accuracy of such disaggregated multipliers, they can be interpreted as useful indicators of the likely employment impacts of the smelter proposals.

The results of this study, show that the total employment impact of the three proposals will be between 2600 and 3500 jobs, with the upper figure being the more likely estimate. The production-induced flow-on impacts will be concentrated in the mining, electricity and transport sectors, but the total flow-ons will be spread more evenly throughout the regional economy.

The total employment impact of the proposals, indicate that a large number of jobs will be generated for males and/or semi and unskilled blue collar workers. Unfortunately, unless steps are taken to change present youth and female participation rates in the regional workforce, the smelter developments will have little impact on the current high unemployment rates amongst females and young people.[2] However, it should be noted that contrary to popular opinion, the proposals will not mainly provide jobs for skilled workers. Indeed, the proportion of skilled labour in the total impact profile of the proposals is considerably less than the current proportion of skilled labour in the workforce. If both white and blue collar jobs are considered over two thirds of the jobs generated by the proposals will be in the semi and unskilled category.

These figures should provide some encouragement for manpower planners, given the present shortage of skilled labour in the Hunter.

In conclusion, it is believed that this paper has demonstrated the flexibility of input-output analysis as a regional planning tool. Not only will input-output tables generate aggregate multipliers, but with some additional data, they can also generate disaggregate multipliers. It is considered that the information conveyed by such multipliers, will be of utility to both regional and manpower planners, in their task of minimising the costs and maximising the benefits of rapid regional development.

NOTES

1 For the sake of brevity, only the operational employment impacts are considered in this paper.

2 At present, over 50 percent of unemployed people in the Hunter are under 21, in comparison to the State figure of about 39 percent. Furthermore, 47 percent of the unemployed are female in comparison to a State figure of about 36 percent.

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AN EVALUATION OF THE BURFORD KATZ SHORT CUT TECHNIQUE FOR DERIVING INPUT-OUTPUT MULTIPLIERS

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Abstract

This paper is concerned with extending understanding of short cut approaches to deriving regional economic multipliers. It focuses on the work of Burford and Katz. Seven regional input-output tables are analysed using the Burford Katz formula. Rules of thumb are developed to assist the regional analyst in making decisions on the appropriateness of applying short-cut formulae in order to estimate input-output multipliers when no input-output table exists.

I. Introduction

It is generally accepted by regional economists that input-output multipliers provide the most comprehensive information concerning the economic impact of any change in the level of economic activity in a particular region. However, it is equally well agreed that input-output analyses are amongst the most data ravenous of all the regional economic models that have been developed. The necessity of acquiring voluminous amounts of data to undertake such analyses have often hindered their application, but this has had the positive effect of spawning a number of techniques which have as their general aim the derivation of input-output multipliers without having to undertake the traditional vast data gathering exercise.

Three broad categories of approaches have been developed to reduce the data input needs of input-output analysis. These include (i) Simplification of regional input-output tables, and thereby the amount of data needed (8). (ii) Manipulation of national input-output tables to formulate regional tables (12). (iii) The use of short cut formulae to estimate regional multipliers. This paper is concerned with the last of these approaches, where a reasonably substantial literature has evolved in recent years. The major contributions to advances in this field have been made by Bromley (1), Salcedo (17), Drake (5), Davis (3), Burford and Katz (2) and Phibbs and Holsman (16). The latter article provides a reasonable summary of most of the work in this area. The authors believe that the most promising of these contributions is the work of Burford and Katz. The aim of this paper is to subject the formulae of Burford and Katz to empirical

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testing, and in so doing to develop rules of thumb which will enable the regional analyst to make an immediate decision on the applicability of such short cut techniques to a particular region. However, in the first instance it is appropriate to outline the earlier work of Burford and Katz.

II. The Burford-Katz Short Cut Method

Burford and Katz begin by equating a power series of A matrix (trade coefficients matrix), with the Leontief inverse. That is

$$(I-A)^{-1} = I + A^1 + A^2 + A^3 + A^4 \dots . A^n \tag{1}$$

They then make use of a rule outlined in Drake (5) which says that a sum of products can be written as the sum of values of one factor times the average value of the other factor plus a covariance term....

$$\sum_{i=1}^{n} X_1 Y_1 = \bar{Y} \sum_{i=1}^{n} X_i + \sum_{i=1}^{n} (X_i - \bar{X})(Y_i - \bar{Y}) \tag{2}$$

Drake postulates that when the covariance term is likely to be very small it can be safely ignored, and therefore, the last term in equation (2) can be removed. Using this rule, Burford and Katz state that when the covariance between the a_{ij}'s and the sums of the intermediate inputs (w_i's) is small or zero then A^2 is approximately equal to αA, A^3 is approximately equal to $\alpha^2 A$, and so on, where α is the mean value of the w_i's.

i.e. $$\alpha = \sum_j \sum_i a_{ij}/n$$

or $$\alpha = \sum_j w_j/_n \tag{3}$$

Therefore

$$\begin{aligned}(I - A)^{-1} &= 1 + \alpha^0 A + \alpha^1 A + \alpha^2 A + \dots \\ &= I + A(\alpha^0 + \alpha^1 + \alpha^2 \dots) \\ &= I + A \sum_{m=0}^{\infty} \alpha^m \end{aligned} \tag{4}$$

If $\alpha < 1$ as it must be in a regional model, then

$$\sum_{m=0}^{\infty} \alpha^m = \frac{1}{1-\alpha}$$

$$\therefore \ (I-A)^{-1} = I + \frac{i}{1-\alpha} A \tag{5}$$

$\therefore$ The multiplier for column j (u_j) is

$$u_j = 1 + \frac{1}{1-\alpha} \sum a_{ij} \tag{6}$$

$$= 1 + \frac{1}{1-\alpha} w_j$$

Thus using Equation (6) output multipliers can be calculated using only the total intermediate inputs as data, provided the covariance between a_{ij} and w_i is very small. Burford and Katz are confident that there is no theoretical and little empirical evidence to suggest that this would not be the case.

In their work Burford and Katz also derive a formula for Type I income multipliers. They begin with the traditional formula for the direct and indirect income effects of an increase in final demand namely:

$$I_j = \sum_{i=1}^{n} u_{ij}\, a_{n+1,i} \tag{7}$$

Where I_j = direct and indirect income effects of an increase in final demand for the output of industry j.

u_{ij} = ijth element of the inverse matrix

$a_{n+1,i}$ = proportion of sector i's total inputs which are payments to households.

or

$$I_j = \sum_{i=1}^{j-1} u_{ij}\, a_{n+1,i} + a_{n+1,j} + (u_{jj}-1)a_{n+1,j} + \sum_{i=j+1}^{n} u_{ij} a_{n+1,j}$$

$$= a_{n+1,j} \quad \sum_{\substack{i=1 \\ i\neq j}}^{n} u_{ij} a_{n+1,i} + (u_{jj}-1)a_{n+1,j} \tag{8}$$

If the $a_{n+1,j}$ and the u_{ij} are uncorrelated then again working from Drake's expression (see Equation 2).

$$I_j = a_{n+1,m} + \bar{a}_{n+1}\left(\sum_{i=1}^{n} u_{ij} - 1\right) \tag{9}$$

where the first term is the direct effect, and the second term is an estimate of the indirect effect.

Burford and Katz use this expression to generate estimates of the direct and indirect effects of changes in final demand in Georgia, and then discover that the mean difference between their estimates and values computed from the Georgia input-output study is one percent. Type I income multipliers are calculated by dividing Equation 9 by $a_{n+1,j}$.

III. Evaluating the Short-Cut Multiplier Method

In order to test the reliability of the short-run formulae of Burford and Katz (Equations 6 and 9), a number of input-output studies, mainly Australian, were selected. For each input-output study estimates of the multipliers were calculated using the short-cut formulae, and these were compared to multipliers derived from the inversion of the full input-output table.

The input-output studies selected were:

(a) Jensen's (10) input-output study of Central Queensland. The area is essentially a rural region, specializing in sheep and cattle, with an active (and growing) coal mining sector. The population density is low with the total population of the study area being 135,000. The Central Queensland model contains 26 sectors.

(b) McCalden's (13) study of Muswellbrook, a small service town in the upper Hunter Valley of New South Wales. The population of the study was approximately 6,500. Muswellbrook acts as a service centre for the surrounding rural region which includes coal mining and wine growing interests in addition to traditional rural activities. The Muswellbrook model contains 17 sectors.

(c) Morrison's (18) study of Peterborough, England. Peterborough is a medium-sized town in the East Midlands of the U.K. The town acts as a regional centre for a predominantly rural area but also possesses a substantial manufacturing sector. In 1967 (when the field work was undertaken) Peterborough had a population of 82,000.

(d) Hooker and Potter's (9) study of Evanston, Wyoming (U.S.A.). The population of the study area was about 4,500, and the town is surrounded by a arid landscape. The town is located on a major interstate highway route. The Evanston model has 19 sectors.

(e) Dickinson's (4) study of Northern Queensland, Australia. The region consisted of the Shires of Ayr, Bowen, Dalrymple, Hinchenbrook and Thuringowa, and the Cities of Charters Towers and Townsville. It had an area of 101,000 sq. km. and in 1976 the population of the region was 145,444. This table has 43 sectors.

(f) Edwards' (6) study of Tasmania. Tasmania is the smallest state in Australia with a population in 1976 of 402,868. Its mineral industries are declining and it lacks a sound manufacturing base. The Tasmanian model has 45 sectors.

(g) Garlick's (7) study of the Hunter Valley Region in New South Wales, Australia. The Hunter Valley possesses a very mixed economy, with the heavy industrial centre of Newcastle, coal mining, vineyards and wheat farming its major characteristics. The region had a population of 418,000 in 1976 and the State's highest unemployment rates. The Hunter Valley possesses 18 sectors.

These studies represent a fairly wide cross section both in terms of population and regional specialisation.

The results of the analyses are shown in Table 1 and are discussed below.

IV. Results of Tests on the Seven Input-Output Tables

i) Output Multipliers

The estimates for the output multipliers are fairly close to the 'correct' multiplier values. Five out of the seven regions have no sectors with errors greater than 10 percent, the largest error is only 12.9 percent. It is held that most analysts would be happy to use such estimates. In general, the largest errors occur when the sum of the intermediate input coefficients (w_j) is large.

TABLE 1

SUMMARY OF THE EMPIRICAL EVALUATION

	Central Queensland	Muswellbrook	Peterborough	Evanston	Northern Queensland	Tasmania	Hunter Valley
No. of Sectors	26	17	19	19	43	45	18
OUTPUT MULTIPLIERS							
Mean Error[a]	6.6395	0.4413	0.1701	-0.2829	0.2671	-2.4493	-1.1832
Absolute Mean Error	6.9062	1.6766	0.3840	2.0447	0.8793	2.6086	1.8577
Maximum Error	10.3936	-6.7381	-1.190	5.2211	-5.4283	6.5849	-12.8629
No. of Sectors with error greater than 10.0%	2	0	0	0	0	0	1
INCOME MULTIPLIERS							
Type 1							
Mean Error	8.1331	-2.3118	-1.676	7.7009	1.5392	-0.3271	0.9738
Absolute Mean Error	13.7664	4.2396	2.307	8.1497	3.5513	3.1646	3.3405
Maximum Error	62.1837	-17.5979	-8.475	58.5284	50.9761	27.6186	-13.9923
No. of Sectors with error greater than 10%	12	2	0	3	1	2	2
Type II							
Mean Error	9.8489	-1.1526	-2.040	10.1543	-1.6993	0.7106	0.8640
Absolute Mean Error	14.9335	3.6031	2.551	10.2897	5.3431	3.5401	3.3009
Maximum Error	64.9234	-18.7425	-8.813	62.0523	46.0944	26.1054	-14.0884
No. of Sectors with error greater than 10%	12	2	0	3	1	2	2

Note a: Where error = $\left[\frac{\text{Short cut multiplier} - 1}{\text{Actual multiplier}}\right] \times \frac{100}{1}$

(ii) Type I Income Multipliers

Differences between the short-cut formula estimates and the 'correct' values for the Type I income multiplier are in most cases small, and hence the mean differences are small. Nevertheless, it cannot be overlooked that in some cases the errors are quite large. Peterborough is the only example where none of the errors is greater than 10 percent. The remaining examples all have at least 2 sectors with errors greater than 10 percent, while Central Queensland has 12 sectors with errors greater than 10 percent. These results are disturbing because the large errors involved in some cases, would seem to render the use of the short-cut formula a non-option unless we can define precisely the limits of its accuracy. Also the results appear to clash with those of Burford and Katz, who tested the formula using the Georgia input-output model, and came up with a maximum error of 9.9957 percent.

However, a closer examination of the results shown in Table 1 and the original data reveals that the largest errors for each region occur i) when w_i is large (sum of intermediate inputs) and/or ii) when h_{oj} is small (household coefficient).

The first case can be explained by referring back to the formula for Type I income multipliers (see Equation 9). The correctness of this formula depends on the covariance between the elements of any column in the inverse matrix and the household coefficients being zero or very small (thereby allowing simplifcation of Equation 2):

i.e. for any sector j, $(u_i, - \bar{u}_i)(h_{oi} - \overline{h_{oi}}) \simeq 0$
where u_i = elements of the jth column of the inverse matrix.

Obviously the assumption of zero covariance will be violated when there is a large variation in the magnitude of coefficients in any column. However, when the sum of the u_i's is small even large variations in the magnitude of the coefficients will not drastically affect the reliability of the short-cut formulae. But when the sum of the u_i's is large, variations in the magnitude of the coefficients can seriously affect the reliability of the short-cut formulae results. Since the size of the sum of the u_i's (i.e., the output multiplier) varies directly with the size of the sum of intermediate inputs, then the error associated with the use of the short-cut formulae is more likely to be large when the sum of intermediate inputs is large.

The second case can be explained by the formulation of the multiplier itself. Since the multiplier is defined by direct plus indirect effects divided by the direct effects of a change in final demand, then it is obvious that a large direct effect will mask the error associated with the indirect effect estimate. However, once the direct effect becomes very small, any error associated with estimating the indirect effect will not be masked, and hence will show up as a large error when the total multiplier is considered.

While the above explanations suggest when the largest error is likely to occur, the problem remains that some regions show small mean errors (e.g., Peterborough) while others (e.g., Central Queensland) show large mean errors. It would therefore be instructive, and useful, to be able to predict when and why such errors might occur. To achieve this aim a closer investigation of Equation

AN EVALUATION OF THE BURFORD KATZ SHORT CUT TECHNIQUE

10 is required. It is clear that the covariance term has a greater chance of being significant, when the second bracketed term ($h_{oi} - \overline{h_{oi}}$) is significantly greater than zero. This is most likely to happen if the variance of the household coefficients is large, and the mean is large. Therefore, other things being equal, it would be expected that larger and more frequent errors would occur when the short-cut formula was applied to regions where the variance and mean of the household coefficients was large, that is when the coefficient of the variation is large. In order to test this hypothesis, the coefficient of variation for each of the selected input-output studies was calculated. These are shown in Table 2. The results support this hypothesis, since the region with the largest number of sectors with errors greater than 10% (Central Queensland), has an extraordinarily high coefficient of variation.

TABLE 2

COEFFICIENT OF VARIATION FOR EACH OF THE SELECTED REGIONS

Region	Coefficient of Variation of the Household Coefficients
1. Central Queensland	.8521
2. Muswellbrook	.5101
3. Peterborough	.5764
4. Evanston	.5730
5. Northern Queensland	.5202
6. Tasmania	.4320
7. Hunter Valley	.4035

It is now possible to summarize the above results, and to formulate guidelines that will identify sectors where the short-cut formulae for Type I income multipliers are likely to produce errors greater than 10 percent, it being considered that ± 10 percent is a reasonable level of accuracy.

The three crucial factors in relation to the size of the error are the size of the w_j, the size of the h_{oj} and its coefficient of variation. A close examination of the data revealed that errors greater than 10 percent were experienced when:

Case 1 - Coeffcicent of variation is less than .6

(a) w_j is one standard deviation greater than the mean
and (b) w_{oj} is more than one-half of a standard deviation below the mean

OR

(a) w_j is greater than the mean
and (b) h_{oh} is more than one-half standard deviation below the mean

Case 2 - Coefficient of variation is greater than .6

(a) w_j is one standard deviation greater than the mean and (b) h_{oh} is less than the mean

OR

(a) w_j is greater than the mean
and (b) h_{oh} is more than half a standard deviation below the mean.

At this stage it is interesting to retrace our steps and examine Burford and Katz's results for Georgia, since their results seem to clash with those presented in Table 1. The coefficient of variation for the household coefficients is extremely small (.4069). Furthermore, applying Case 1 of the above guidelines, whenever a sector had a w_j one standard deviation greater than the mean the corresponding h_{oj} was never greater than one-half of a standard deviation below the mean. Also no h_{oj}'s were more than one-half of a standard deviation below the mean. Therefore, the Georgia study can be seen as somewhat a special case, and hence the errors associated with the use of the short-cut formula for Type I income multipliers were exceptionally small in the Georgia example.

V. Conclusion

The major conclusion of this paper is that the utility of the Buford and Katz formulae is more limited than their proponents originally claimed. The present paper has sought to clarify those situations when the Burford Katz formulae can be applied with reasonable accuracy. In so doing it is believed the value of this particular short-cut technique in input-output analysis is enhanced and gains greater credibility. Of more significance, perhaps, is the belief that through the achievement of greater precision in the applicability of short-cut techniques, sound regional analytical tools become available to a wider range of planning and research agencies.

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Estimating input-output multipliers—a new hybrid approach

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Abstract. A new hybrid input-output technique known as GRITSSIC is proposed. The method uses survey-based sums of intermediate coefficients to improve the accuracy and reliability of generalised regional input-output tables. A series of simulation tests and empirical verification through the application of the technique to the Hunter Valley region of New South Wales suggest that GRITSSIC achieves a satisfactory compromise between reliability and cost efficiency.

1 Introduction

It is generally accepted by regional economists that input-output multipliers provide the most comprehensive information concerning the economic impact of any change in the level of economic activity in a particular region. However, it is equally well agreed that input-output analyses are amongst the most data-ravenous of all the regional economic models that have been developed. The necessity of acquiring voluminous amounts of data to undertake such analyses has often hindered their application, but this has had the positive effect of spawning a number of techniques which have as their general aim the derivation of input-output multipliers without having to undertake the traditional vast data-gathering exercise.

Three broad categories of approaches have been developed to reduce the data input needs of input-output analysis. These include:
(a) manipulation of national input-output tables to formulate regional tables;
(b) use of the shortcut formulae to estimate regional multipliers; and
(c) hybrid techniques, involving some use of national tables.

The first approach has been discounted by many, notably Schaffer and Chu (1969), as being unable to generate accurate input-output multipliers. The shortcut formulae approach initially showed great promise. The major contributions in this field have been made by Bromley (1972), Salcedo (1972), Drake (1976), Davis (1976; 1978), Burford and Katz (1977), and Phibbs and Holsman (1980). The latter article provides a reasonable summary of most of the work in this area. Unfortunately, none of the techniques have stood up to rigorous empirical testing (see Latham and Montgomery, 1979). The technique developed by Burford and Katz, was probably regarded as the most promising of the shortcut methods, but recent work (Phibbs and Holsman, 1981) has shown that this technique is unreliable in certain circumstances, generating large, unsystematic errors.

Richardson (1972) suggested that the third approach has the greatest potential in achieving the aim of providing reliable, but cost-efficient, multipliers. However, to date, the potential of these techniques has not been realized. Su's (1970) survey of imports technique and the RAS technique (DAE, 1963) have been heavily criticised (see Malizia and Bond, 1974; Czamanski and Malizia, 1969; Schaffer, 1970). A more recently developed hybrid technique—the GRIT technique—(Jensen et al, 1977) as yet remains untested. Nevertheless, its dependence on the location-quotient technique would suggest that its accuracy is questionable.

The aim of this paper is to outline a new hybrid technique which the authors believe achieves a satisfactory compromise between reliability and cost-efficiency.

The method, named GRITSSIC—generalized regional input-output tables with survey-based sums of intermediate coefficients—is specified in section 2. Section 3 outlines the results of simulation tests undertaken using the new method, and section 4 describes a detailed empirical test of the method.

2 The GRITSSIC technique

Various shortcut techniques, particularly those of Phibbs and Holsman (1980) and Burford and Katz (1977), have highlighted the importance of the sum of intermediate coefficients in affecting the value of sectoral multipliers. However, as mentioned in the introduction, the applicability of such techniques has been found to be limited. For example, the Burford-Katz formulae fail to give reliable results for a particular sector when there is a large variation in the size of input coefficients, since this results in violation of their assumption of zero covariance. However, since in many cases reliable I-O multipliers could be generated with the sum of the intermediate coefficients alone, it seemed sensible to persevere with the approach, but to find some way of improving the reliability of the method.

It is now considered that one way of improving the 'sum of intermediate inputs' approach is to combine the sum of intermediate coefficients with a rough approximation of a regional input-output table. That is, an approximation of a regional input-output table could be generated, for example, by a simple location-quotient technique. This table would then be adjusted so that its column sums tallied with survey-based sums of intermediate inputs. The input-output multipliers could then be calculated in the normal manner. This procedure is henceforth referred to as GRITSSIC.

It is suggested that such an operation would generate multipliers which are more reliable than those generated by simple shortcut formulae techniques. In order to test this method, simulation tests were undertaken. These are discussed below.

3 Simulation tests of GRITSSIC

In order to test the feasibility of the GRITSSIC technique, a number of simulation tests were undertaken, using Hooker and Potter's (1970) Evanston table as a reference point.

The first simulation test involved generating a number of 'random' direct coefficient matrices, subject to the following constraints:

(a) the generated coefficient fell within a certain percentage range (from 10-100) of the corresponding coefficient from the Evanston table;

(b) the coefficient was greater than zero; and

(c) the sum of the generated intermediate coefficients for any sector was equal to the sum of intermediate coefficients for the corresponding sector of the Evanston table.

The generation process was repeated fifty times. The Leontief inverse was computed for each generation and the output and type 1 income multipliers were calculated. These multipliers were then compared with the 'true' Evanston multipliers[(1)]. The results of this analysis are shown in table 1.

This table shows that the generated output multipliers are good approximations of the 'true' multipliers, even when the direct coefficients are allowed to vary by up to 100% from the correct value. The maximum error is only 15·8%. Income multipliers are more sensitive to changes in direct coefficients. In order to keep the error between the generated multipliers and the 'true' multipliers below 10% for all sectors, the maximum coefficient deviation cannot be larger than 10%. However, for most of the sectors the error associated with the generated multiplier estimates is fairly small even when the maximum deviation is high. For example, when the maximum deviation is 50%, the maximum error for sixteen of the nineteen sectors is under 11%.

Three sectors experience consistently large errors, namely sectors 1, 3, and 12. Sections 1 and 3 have the highest sum of intermediate inputs of the whole table (0·4458 and 0·15310 respectively). Moreover, they are characterized by very large input coefficients for sector 4, the wholesaling sector. This means that a small percentage deviation will have a large impact in absolute terms. Sector 12 has a smaller sum of intermediate coefficients (0·1292), but it is characterized by a dominating wholesale input coefficient (0·1154) and a small household coefficient.

Table 1. Results of simulation test 1. The error is given by 100[1 − ('generated' multiplier/correct multiplier)], and ame and me stand for absolute mean error and mean error, respectively, in percent.

Sector	Errors for maximum deviations of							
	10%		25%		50%		100%	
	ame	me	ame	me	ame	me	ame	me
Output multipliers								
1	0·1994	1·2575	0·4797	3·0866	1·0203	4·0439	2·0204	12·9155
2	0·0457	0·2067	0·1034	0·3063	0·2395	1·4656	0·5238	1·9652
3	0·2315	1·0948	0·4923	3·9482	1·1894	5·7671	3·0369	15·7896
4	0·0144	0·0432	0·0381	0·1507	0·0515	0·1587	0·1580	0·6622
5	0·0646	0·1481	0·1615	0·5062	0·2060	0·7240	0·4963	1·5128
6	0·0473	0·2481	0·0625	0·2726	0·1087	0·7517	0·2742	1·4793
7	0·0566	0·1692	0·1302	0·4657	0·2384	0·8745	0·4757	2·3354
8	0·0347	0·1689	0·0843	0·2972	0·1607	0·4933	0·4409	1·2116
9	0·0300	0·0871	0·0788	0·2847	0·1231	0·4003	0·2526	1·6987
10	0·1909	0·4956	0·5381	1·3333	0·9509	2·2566	1·8715	4·3185
11	0·0250	0·0676	0·0616	0·2962	0·1196	0·3645	0·2330	0·6852
12	0·0857	0·3434	0·1921	1·2089	0·3642	2·3879	1·0619	5·3310
13	0·0223	0·1154	0·0607	0·3249	0·1302	0·4270	0·2228	1·0345
14	0·0202	0·0547	0·0257	0·0962	0·0447	0·2758	0·0890	0·8589
15	0·0460	0·1852	0·0781	0·3224	0·1651	1·0305	0·2526	1·0909
16	0·0365	0·1375	0·0449	0·1731	0·1577	0·6906	0·1975	0·9406
17	1·2761	1·3336	1·2620	1·4047	1·2423	1·4908	1·1795	1·6956
18	0·0769	0·2403	0·1758	0·7306	0·3582	1·0136	0·6541	2·2040
19	0·1353	0·4346	0·3346	0·9311	0·6254	1·5057	1·2533	3·9111
Type 1 income multipliers								
1	2·0633	7·3458	5·7130	28·7698	13·0061	52·4125	28·0612	91·1746
2	0·2905	0·9808	0·5429	1·7023	1·2330	5·9930	2·2955	8·8264
3	1·4487	5·0357	3·2322	17·2458	8·6487	33·0391	21·1605	65·2708
4	0·1609	0·6891	0·3537	1·1132	0·6203	2·3998	1·5508	6·7630
5	0·3141	1·4107	0·9929	3·8669	1·6072	6·3304	3·6095	14·0041
6	0·2647	1·7419	0·5697	3·0253	1·0834	5·7151	2·2255	8·7033
7	0·1749	0·5578	0·3684	2·3456	0·8753	4·7709	1·1668	4·9578
8	0·1846	0·6301	0·3962	0·9204	0·7937	2·3005	1·4852	5·2982
9	0·0693	0·2217	0·2297	0·6162	0·3055	0·9524	0·6640	1·9067
10	0·5229	2·8155	0·2077	0·6053	2·6023	10·1917	4·7276	12·8013
11	0·2034	1·0791	0·6224	2·3997	1·3553	9·0033	1·8997	6·1653
12	1·1208	1·6774	2·6971	14·9136	5·3349	26·4798	14·8615	63·2918
13	0·0963	0·3135	0·2071	0·6120	0·4101	2·0214	0·8149	2·1659
14	0·0922	0·5742	0·2155	1·0125	0·4275	1·3431	0·5573	1·7693
15	0·0616	0·2654	0·1563	0·5502	0·3470	2·3689	0·5325	2·1348
16	0·0910	0·2848	0·1921	0·7458	0·3930	1·6090	0·7623	3·3882
17	0·1651	0·3991	0·4850	1·9966	0·8626	2·9687	1·7432	6·7744
18	0·2155	0·8925	0·5600	2·0576	1·0190	4·1757	2·1648	6·8184
19	0·2719	1·0143	0·4660	1·5557	1·0852	5·2727	2·5046	11·2667

The algebraic structure of the type 1 multiplier means that a small household coefficient exposes multiplier estimates to error, even when the error associated with the sum of the direct and indirect effects is small.

On the basis of these encouraging results, another simulation test was devised to test the hypothesis that multipliers for any one sector are largely independent of the direct coefficient entries for the remaining sectors. If this hypothesis proved correct, then it would not be necessary to ascertain by survey the sum of intermediate coefficients for *all* the sectors in a table, but rather only for the sectors of special interest to the analyst(2). This hypothesis was suggested by earlier work by Phibbs and Holsman (1980) on a generalised trade-coefficients matrix.

This hypothesis was also tested by generating a 'random' direct coefficients matrix for a ten-sector table, but this time the constraints varied between sectors.

For each set of random generations (with fifty generations per set), multipliers were calculated for only sector *j*. For this sector the following constraints applied:
(a) the generated coefficient fell within a 10% range of the corresponding coefficient from the Evanston table;
(b) the coefficient was greater than zero; and
(c) the sum of the generated intermediate coefficients for any sector was equal to the sum of intermediate coefficients for the corresponding sector of the Evanston table.
For the other eighteen sectors, the constraints were
(a) the generated coefficient fell within a certain percentage range (from 10–100%) of the corresponding coefficient from the Evanston table; and
(b) the coefficient was greater than zero.

Table 2. Results of simulation test 2.

Sector	Output multipliers			Type 1 income multipliers		
	absolute mean error (%)	absolute mean error—test 1 (%)[a]	maximum error (%)	absolute mean error (%)	absolute mean error—test 1 (%)[a]	maximum error (%)
1	0·2432	0·1994	0·5601	2·8027	2·0633	10·7895
2	0·3184	0·0457	0·8456	0·3814	0·2905	1·2923
3	0·3458	0·2315	1·1834	1·4390	1·4487	5·5512
4	0·0923	0·0144	0·2356	0·3152	0·1609	0·9450
5	0·4310	0·0646	1·0335	0·7644	0·3141	2·1172
6	0·0791	0·0473	0·4553	0·2272	0·2647	1·3801
7	0·4411	0·0566	1·5474	0·2922	0·1749	1·0831
8	0·2081	0·0347	0·6271	0·2083	0·1846	0·6906
9	0·2163	0·0300	0·5498	0·1625	0·0693	0·4888
10	0·2060	0·1909	0·6462	0·4854	0·5229	2·7243
11	0·1510	0·0250	0·4625	0·2153	0·2034	0·6427
12	0·0830	0·0857	0·2997	1·0883	1·1208	3·7388
13	0·0768	0·0223	0·2353	0·0986	0·0963	0·5710
14	0·0269	0·0202	0·0995	0·1135	0·0922	0·6179
15	0·0766	0·0460	0·3420	0·0808	0·0616	0·3534
16	0·1073	0·0365	0·3233	0·1043	0·0910	0·3311
17	1·2841	1·2761	1·4999	0·2082	0·1651	0·5680
18	0·2597	0·0769	0·6578	0·2996	0·2155	0·8834
19	0·9381	0·1353	2·7438	0·7351	0·2719	1·9631
Mean	0·2939	0·1389		0·5275	0·4111	

[a] That is, the absolute mean error obtained from simulation test 1 with a maximum deviation of 10%—see second column of table 1.

(2) Hereafter referred to as the 'interest sectors'.

The Leontief inverse was computed for each generation and the output and type 1 income multipliers were calculated for sector j. These 'generated' multipliers were then compared with the 'true' Evanston multipliers.

This process was repeated nineteen times, after which generated multipliers existed for all nineteen sectors.

The results of this analysis are shown in table 2. The table shows the results for the simulation test when the maximum deviation for sectors, other than the jth sector, was set at 50%. The maximum deviation for the jth sector was set at 10%. The third and sixth columns in the table show the absolute mean error, for the 10% maximum deviation, of the original simulation test (that is, taken from table 1).

The table clearly demonstrates that the lower level of accuracy for the non-j sectors in the stage 2 simulation has only a minimal impact on the accuracy of the multiplier estimates. For example, the average of the absolute mean error for income multipliers increases from 0·4111 for the first simulation test, to only 0·5275 for the second.

In summary, the simulation tests support the GRITSSIC technique. Moreover, the second simulation test has led to a refinement of the technique since it has been shown it is not necessary to obtain survey-based sums of intermediate coefficients for all sectors. Nevertheless, it must be appreciated that although simulation tests are useful, the real test of the applicability of a method is whether it is able to generate reliable multiplier estimates under normal operational conditions. It is to such a test that we now turn.

4 An empirical evaluation of the GRITSSIC technique

The empirical evaluation of the GRITSSIC technique essentially involved generating a set of GRITSSIC multipliers and comparing these multipliers with a set of multipliers derived from a survey-based input-output table.

The survey-based input-output table used in this evaluation is one for the Hunter Valley region of New South Wales and was compiled by Garlick (1979). Garlick's table consisted of eighteen sectors and was based on a comprehensive survey of the region.

The approximate regional input-output table was generated using the GRIT algorithm developed by Jensen et al (1977)[(3)]. GRIT generates regional tables from a national input-output table by means of a modified location-quotient technique. A preliminary version of the 1974-1975 national input-output table was used as a starting point, and from this national table an approximate Hunter Valley regional table was generated using the GRIT algorithm and 1976 Census data. The table had nineteen sectors.

A mail survey was used to estimate the sum of intermediate coefficients for eleven interest sectors: one mining, nine manufacturing, and one building and construction sector; and the household and employment coefficients for all nineteen sectors. The response for the mail survey was good and, indeed, better than other input-output mail surveys undertaken in Australia. For example, for the nine manufacturing sectors, the percentage of the region's manufacturing employment represented by the returned forms was over 55%. This good response rate can be explained by the small amount of survey information required by the GRITSSIC technique in comparison to traditional input-output surveys.

Before direct comparison between Garlick's multipliers and those based on the GRITSSIC methodology could be made, it was necessary to make two adjustments to

(3) It should be stressed that the GRIT technique used was the simplest version of Jensen et al's original formulation.

the input–output tables. First, Garlick's table was converted to basic values, since this is the accounting system used in the GRIT algorithm. Second, GRITSSIC multipliers were calculated by use of Garlick's income and employment coefficients. This procedure was adopted since it was discovered that some large anomalies were present in Garlick's income and employment coefficients owing to an ambiguous instruction in his original survey form. In order to control for these anomalies, and hence subject the GRITSSIC technique to a fair test, it was decided to use the one set of income and employment coefficients for both tables.

A comparison of Garlick's multipliers and those based on GRITSSIC, after the above adjustments were made, is given in table 3. In addition, multipliers associated with the approximate Hunter Valley table, based on GRIT, are shown. The percentage error between Garlick's multipliers and the other estimates is also given. Output, type 1 income, and type 1 employment multipliers are indicated in table 3.

Table 3 shows that the GRITSSIC multipliers are reasonably close to Garlick's multipliers. For output multipliers the maximum difference is under 11%, for income multipliers it is under 10%, whereas for employment multipliers it is under 13%, with the absolute mean error for all multipliers being below 6%. In contrast, the multipliers associated with the regional table generated by the GRIT algorithm are subject to considerably greater error. The maximum difference between these multipliers and Garlick's multipliers is as high as 68·7% for output multipliers, 171% for income multipliers, and 192% for employment multipliers[(4)]. It is interesting to note that the GRIT procedure yields type 1 income multipliers which are on average 20·77% higher than Garlick's values. This result compares with corresponding figures of 21% obtained by Schaffer and Chu (1969) and 20% by Morrison and Smith (1974) when they tested the simple location technique against survey results.

It is considered that the accuracy of the GRITSSIC technique demonstrated in this empirical test is sufficient to warrant its further use and development as a generalised method for estimating input–output multipliers. It is contended that GRITSSIC is a cost-effective alternative to traditional input–output studies. For example, the GRITSSIC tables for the Hunter Valley were produced at about one-tenth of the cost of Garlick's survey-based tables. Moreover, although traditional survey-based tables can take anything up to two years to complete, GRITSSIC multipliers can be produced in approximately three months.

5 Conclusions

This paper has considered the alternative methods of deriving input–output tables and proposes a new hybrid technique, GRITSSIC. The insertion of survey-based data of intermediate coefficients in a regional table derived from a location-quotient approach achieves accuracy and efficiency with a considerably reduced cost outlay.

The technique has been appraised by means of simulation tests and more importantly by comparison with an input–output table derived by traditional survey methods. The results of the empirical evaluation are extremely encouraging. The maximum difference between GRITSSIC and survey-based multipliers is under 13%, with the absolute mean error for all multipliers being below 6%. Both these percentage errors represent considerable improvements on results obtained by the simple location-quotient approach. Although it is accepted that one empirical test is usually an insufficient basis on which to make a claim for the general utility of a technique, the authors believe that the sound theoretical underpinning of the procedure advanced above is reason enough to be confident in this instance.

[(4)] It is interesting to note, however, that the errors are not spread evenly over all sectors. In particular, the GRIT error for the tertiary sectors is dramatically lower than for the manufacturing sectors.

Table 3. A comparison of GRITSSIC and survey-based input–output multipliers[a].

Sector	Simple output multiplier	Error (%)	Total output multiplier	Error (%)	Type 1 income multiplier	Error (%)	Type 2 income multiplier	Error (%)	Type 1 employment multiplier	Error (%)	Type 2 employment multiplier	Error (%)
2 Mining	1·2928	−7·25	1·6175	−8·49	1·2376	−4·39	1·4824	−4·89	1·3706	−4·59	1·7863	−9·83
3 Food, beverages, and tobacco	1·5693	−7·63	1·8422	−9·31	1·4522	−9·63	2·3384	−10·11	2·0295	−12·33	2·2930	−14·44
4 Textiles, clothing, and footwear	1·0835	−2·47	1·3244	−3·78	1·0723	−0·11	1·2844	−0·64	1·0751	−0·07	1·3288	−4·67
5 Basic metal	1·2618	−7·51	1·4982	−8·91	1·2640	−7·30	1·5260	−7·79	1·2547	−6·52	1·5212	−10·62
6 Fabricated metal products and transport equipment	1·2538	−8·67	1·5267	−10·10	1·2234	−7·71	1·4655	−8·20	1·2805	−7·72	1·6193	−12·34
7 Chemicals, petroleum, and coal products	1·1375	2·68	1·1863	1·84	1·4306	−5·86	1·7136	−6·37	1·4898	−4·04	1·8191	−8·61
8 Glass, clay, and other nonmetallic mineral products	1·2149	−6·04	1·3737	−7·08	1·3603	−5·73	1·6294	−6·23	1·2135	−4·51	1·3993	−7·79
9 Wood, wood products, furniture	1·3051	4·49	1·5508	3·27	1·3541	6·99	1·6219	6·43	1·3554	8·88	1·5537	5·20
10 Paper and paper products, printing	1·1583	2·28	1·4649	−0·11	1·1113	1·00	1·3312	0·46	1·1020	0·50	1·3215	−8·44
11 Other manufacturing	1·2319	−10·61	1·5067	−11·64	1·2043	−7·56	1·4426	−8·05	1·1772	−5·39	1·3965	−9·38
13 Building and construction	1·3337	−5·13	1·6375	−6·05	1·2587	−0·79	1·5077	−1·31	1·4757	−0·34	1·9158	−5·91
Mean absolute error		5·89		6·42		5·19		5·50		5·41		8·38

[a] Error (%) is given by $100\left(\dfrac{\text{GRITSSIC multiplier}}{\text{Garlick's multiplier}} - 1\right)$.

It is accepted that no shortcut technique can be expected to mirror the accuracy of traditional survey-based methods of producing input-output tables. However, time and monetary resources are not always available for such traditional surveys, and a real need exists for a technique which will provide accurate multipliers at reasonable cost. The GRITSSIC method fulfils both these objectives and in so doing it should allow an improved understanding of regional economies and lead to more accurate assessment of the impact of new development.

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APPENDIX 2.

USING THE ANALYSIS OF WEST TO EXPLAIN THE RESULTS OF THE SIMULATION STUDIES DISCUSSED IN CHAPTER 2.

The major findings of each of the simulation studies discussed in Section 2.5 are presented and an attempt made to explain the findings, using West's analysis which is outlined in the same section. In some cases, it is necessary to re-examine the original research associated with the simulation studies in order to achieve consistency with West's work.

1. WEST AND JENSEN (1977)

Finding (i) The instability of output multipliers is related to the size of the output multiplier

It has long been realised in input-output analysis, that positive and negative errors in direct coefficients maintain their sign through the inversion process, so that the resultant multiplier error tends to be minimised. According to Evans (1954;461) this means that the input-output model has an:-

"inherent ability to minimise the undesirable effects of data imperfections"

The operation of this mechanism can be readily demonstrated by referring to equation 2.13. Assume that we have a 2 sector input-output table, and we are interested in examining the impact of a fixed proportional error in the direct coefficients of sector 1 on the multiplier value of that sector. Further assume that the error for one coefficient is negative and for the other coefficient positive, and the direct coefficients of sector 1 are of equal size. From Equation 2.13, absolute multiplier error for sector 1 is:-

$$\begin{aligned} e &= om_1 . a_{11} . p_{11} . b_{11} + om_2 . a_{21} . -p_{21} . b_{11} \qquad 2.14 \\ &= 0 \end{aligned}$$

The errors in the direct coefficients cancel each other out, so that there is no net impact on the multiplier value. However, when the size of the direct coefficients is not equal and the number of negative and positive errors do not balance - which is the more realistic scenario - the size of the multiplier error is affected by the size of the output multiplier. This is because larger output multipliers are associated with larger direct coefficients, which will tend to have an inflationary effect on the size of the multiplier error. Thus West and Jensen's first finding is adequately explained by West's analysis.

Finding (ii) The stability of the error in output multipliers is related to the extent to which individual coefficients dominate their respective columns in the direct coefficients matrix.

The explanation of this finding is relatively straightforward. Even if the signs of the error matrix P balance, (i.e. there are an equal number of positive and negative errors) a dominant entry in the input column of a sector will mean that the value of the plus and minus terms will sum to a significant positive or negative value. Hence, the total multiplier error, as measured by Equation 2.13, will be large.

2. JENSEN AND WEST (1980)

Finding (i) The effects of smaller coefficients are relatively insignificant in the formation of multipliers.

Jensen and West reached this conclusion after they removed small coefficients from several input-output tables, or in other words the p_{ij} term in Equation 2.13 was set to -1.0. It is clear from Equation 2.13 that small coefficients would have a negligible impact on proportional multiplier error. For example, if it is assumed that :-

$$om_i = 2.0$$

$$a_{ij} = 0.0010$$

$p_{ij} = -1.0$

$b_{jk} = 1.1$

$om_k = 2.0$

then from Equation 2.13 the resultant change in the k^{th} multiplier is equal to a proportional decrease of 0.11 percent.

Finding (ii) The larger coefficients in a more connected table appear to be relatively more important then the larger coefficients in a less connected table.

Assuming that the a_{ij} and p_{ij} terms are equal it is relatively easy to see why the situation arises. In a more connected table the increased value of the om_i term will lead to larger porportional multiplier errors.

3. BURFORD AND KATZ (1977)

Finding: If the column sum is fixed and random matrices generated using this column sum, then the resultant multiplier values are fairly similar.

In this case, the $a_{ij}p_{ij}$ terms sum to zero. This provides an inbuilt mechanism for limiting error, although error is still generated as a result of different values in the om_i and b_{jk}/om_k terms. If there was a constant value for these terms across sectors, no error would occur.

4. PHIBBS AND HOLSMAN (1982)

Finding (i) When column sums are set to the 'true' value, the largest errors are generated when there are large column sums and dominant input coefficients.

From Equation 2.13 it can be seen that the dominating coefficent itself is not a problem by itself, since the column sum condition means that $a_{ij}.p_{ij}$ terms add to zero. However, large errors will be generated when the dominating $a_{ij}.p_{ij}$ term is associated with om_i and/or b_{jk}/o_{mk} terms a long way from the mean. For example, the output multiplier for the wholesaling sector in the bechmark input-output table used by Phibbs and Holsman, - the dominant input sector for the three sectors with large errors - was 1.22 standard deviations below the mean. That is, Phibbs and Holsman's finding is not a generalised result, but only applies when the dominant input coefficient is associated with om_i and b_{jk}/o_{mk} terms which are distant from their mean values. For the benchmark table this scenario applied and as a result the multiplier errors were large.

This explanation shows the usefulness of having a theoretical framework to explain multiplier error, and highlights the problems in generalising from region-specific simulation studies.

Finding (ii) In examining the error in output multiplier j, errors in the direct coefficients of non-j sectors are relatively unimportant.

Equation 2.13 provides a simple explanation of this finding. The error terms for the non-j coefficients do not contain a diagonal term of the inverse matrix since j cannot be equal to k. Therefore, instead of having a value greater than 1, the b_{jk} term is substantially less - normally in the Australian situation less than 0.3. As a result the total proportional multiplier error is considerably less than when the coefficient error occurs in the j sectors.

5. STEVENS AND TRAINER (1976) AND PARK ET AL (1981)

Finding (i) Errors in multipliers are much more sensitive to errors in regional purhase coefficients than to errors in technological coefficiets.

This finding is similar to the Burford and Katz finding and is adequately explained above.

Finding (ii) Errors in multipliers can be reduced substantially by survey data for just the sectors impacted in the first round.

This finding is related to finding (ii) of Phibbs and Holsman, and the same explanation applies. If errors in the direct input coefficients of the sector for which a multiplier is being calculated are minimised then the potential for total proportional multiplier error is considerably reduced. This is because the terms in Equation 2.13, associated with error in these coefficients, is relatively large since the b_{jk} element is always greater than 1. Conversely, as detailed in finding (ii) of Phibbs and Holsman's research, errors in the remaining coefficient have a relatively small impact on total proportional multiplier error.

<u>Finding (iii) Errors in output multipliers are quite sensitive to errors in household coefficients.</u>

This finding is readily explained by reference to equation 2.13. In assessing the impact of a change in household coefficients on the output multiplier of any sector, equation 2.13 would take the following form:-

$$el_{ij}^{k} = om_i.a_{in}.p_{in}.b_{nk}/om_k \qquad 2.14$$

where n is equal to the household sector.

This expression will generate a large value in relation to errors in other direct coefficients, since the b_{nk} term is normally much larger than any other elements of the inverse matrix, with the exception of the diagonal elements. Thus the potential exists for large multiplier errors associated with reasonably small errors in household coefficients.

6. HAMILTON (1979)

Finding:- When absolute errors are considered, the resultant multiplier error is related to the size of the diagonal element and the row total.

When absolute errors are considered, the $a_{ij}.p_{ij}$ term in equation 2.13 is replaced by a constant d. The presence of the b_{jk} term in equation 2.13 explains the significance of the diagonal term, but the importance of the row total is puzzling. However, a close look at Hamilton's results (Table D,E,F of his Appendix) reveals that there is a close correlation between om_i values and the row totals - that is, sectors with large regional purchases also have large regional sales. Thus, whilst Hamilton thought multiplier error was related to row totals, the om_i values are actually the direct link with the generation of error (See Equation 2.13).

This explanation again highlights the problem of trying to generalize from simulation studies. In regions where there are sectors with large regional sales, but not large regional purchases, Hamilton's findings would not apply.

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