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Input-Output Analysis in Australia: An Agricultural Perspective

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This paper surveys the Australian history, development and applications of Leontief's input-output system. A strong agricultural/regional association with the technique is found to exist, both in terms of compilation and application of input-output tables. It is also found that while interest in the technique was historically the domain of a number of disparate individuals, in recent years there has emerged a wider involvement of Government agencies such as the Industries Assistance Commission at the Federal level and the various State Government Departments responsible for economic analysis. The paper concludes with a review of current developments.

1. The Input-Output Technique

Although it has been around as long as Keynes' *General Theory*, the Leontief input-output (I-O) system did not gain the same acceptance in Australia that it enjoyed overseas until the 1970's. Initially, the technique attracted no official support, and the early efforts by individual analysts were devoted almost entirely to estimation or compilation of the tables themselves. It has been suggested (in passing) by one such analyst that a possible reason for the lack of policy applications in the early years is that people were too exhausted from the data gathering effort involved in compilation to have any energy left for applications.

1.1 The Nature of Input-Output¹

The basic building block of the I-O technique is the transactions table which traces out the value of transactions between various sectors of an economy for a given year. These sectors are usually broad industrial or commodity groupings such as "Cereal Grains" or "Bread, Cakes and Biscuits". Sectors sell their output of goods and services to other sectors for use in production (intermediate transactions) and to final users such as Households, Government, Exports and Capital Accumulation. These latter final categories are known as *final demand*. Inputs into production are shown as purchases by sectors and may comprise purchases of either intermediate goods or primary inputs such as the services of labour, capital and other items of value added².

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¹ There are numerous texts and other publications which provide details of the I-O technique. Examples are Miernyk (1965), and O'Connor and Henry (1975). The summary in this section draws heavily on West, Wilkinson and Jensen (1979, Chapter 2).

² Readers may note a correspondence of terms in I-O with those common in National Accounts. In many countries the compilation of I-O data is done within the National Accounts section of the Central Statistical Office.

Table 1: *Highly Aggregated Transactions Table, Queensland, 1973-4 (\$m)*

	Intermediate sectors			Household consumption	Other Final demand	Total output	
	1	2	3				
Intermediate sectors	1	129.1	703.5	20.6	102.4	864.3	1 819.9
	2	242.5	778.6	359.2	762.2	1 897.3	4 039.8
	3	224.0	503.2	536.7	1 434.2	1 325.5	4 023.6
Households	..	191.6	946.9	1 660.4	2 798.9
Other Primary Inputs	..	1 032.7	1 107.6	1 446.7	500.1	429.2	4 516.3
Total	..	1 819.9	4 039.8	4 023.6	2 798.9	4 516.3	17 198.5

Source: West, Wilkinson and Jensen (1979, p. 6)

An example of a highly aggregated three sector³ transactions table for the Queensland economy for 1973-74 is shown in Table 1. Reading across the first row it can be seen that sector 1 sold \$129.1 m of its output to firms in the same sector, \$703.5 m to sector 2, \$20.6 m to sector 3, \$102.4 m to Households for consumption purposes and \$864.3 m to other final demand (including inventory changes). Total output for sector 1 was \$1,819.9 m. The figures in the second and third rows represent the corresponding sales by sectors 2 and 3 respectively.

The figures in the first three columns of Table 1 measure the input purchases by the three sectors. Thus sector 2 purchased \$703.5 m from firms in sector 1, \$778.6 m from firms in the same sector, \$503.2 m from firms in sector 3, \$946.9 m from Households (representing payments for labour) and \$1,107.6 m in the form of other primary inputs. Because this last input includes the Gross Operating Surpluses of firms, total input for any sector is equal to total output for the same sector.

The transactions Table 2 can be viewed as a systematic way of representing the Social Accounts of an economy and may provide useful information on industrial structure which is not available from the more usual aggregated account. The accounting problems which are normally faced in compiling a transactions table include, in particular:

- (i) the valuation problem—should transactions be valued at the prices paid by purchasers or at the prices received by producers, the difference being margins associated with transport, wholesale/retail trade and indirect taxes?

³ The Australian I-O tables, as compiled by the Australian Bureau of Statistics, have 109 sector groupings. The choice of number of sectors is often dictated by data availability and objectives of the study, the trade-off frequently being between detailed information (many sectors) and consistency in sector behaviour (few sectors). For a discussion of these issues, see United Nations Statistical Office (1973, pp. 40-42).

- (ii) the treatment of imports—should imports be shown as a primary input into the sector using the import (known as direct allocation), or should they be grouped with domestic products of a similar type (indirect allocation)?

A discussion of the effects of different choices on these two problems is contained in Jensen (1978).

Transactions between intermediate sectors are usually regarded as being endogenous to the economy under consideration. The model is said to be “open” when the Households sector is treated as exogenous.

Closure with respect to Households is often made by treating Household income (normally wages and salaries) and Household expenditure (consumption) as endogenous transactions.

The step from an accounting device to an economic model is made by use of some fairly simple and well known mathematics. Each endogenous row of the transactions table is represented as an equation thus:

$$(1) X_i = \sum_{j=1}^n X_{ij} + Y_i \quad \text{for } i = 1, 2 \dots n$$

where X_i = total output of sector i ,

X_{ij} = output of sector i purchased by sector j ,

Y_i = total final demand for the output of sector i ,

n = the number of endogenous sectors.

Equation (1) may be re-written as:

$$(2) X_i = \sum_{j=1}^n a_{ij} X_j + Y_i \quad \text{for } i = 1, 2 \dots n$$

where $a_{ij} = X_{ij}/X_j$ and measures the input from sector i to sector j per unit of output of sector j . The a_{ij} 's are known as input-output coefficients or technical coefficients and are conventionally assumed to be constant over the time and range of output relevant for the analysis being performed.

Equation (2) may be re-written in matrix form and manipulated as follows:

$$(3) X = AX + Y$$

$$(4) X(I - A) = Y$$

$$(5) X = (I - A)^{-1} Y = ZY$$

where A is the matrix of I-O coefficients, I is the $n \times n$ identity matrix, and Z is referred to as the Leontief inverse. The inverse corresponding to the transactions table in Table 1 is shown as Table 2.

Table 2: $Z = (I - A)^{-1}$, Queensland, 1973-4

	1	2	3
1	1.116	.246	.032
2	.205	1.304	.136
3	.188	.222	1.178
Total ..	1.509	1.772	1.346

Source: West, Wilkinson and Jensen (1979, p. 10).

The figures in Table 2 may be interpreted as follows: for every \$1m of output that sector 1 sells to final demand, sector 1 itself must produce \$1.116m, sector 2 must produce \$0.205m, and sector 3 must produce \$0.188m. These figures measure the direct and indirect input requirements necessary throughout the economy if sector 1 is to sell the \$1m to final demand. The total output required throughout the economy for this purpose is \$1.509m. The power of the I-O technique is readily seen from these figures. Firstly, it provides more comprehensive information than might be expected from a partial equilibrium approach, concentrating on sector 1 only. Secondly, it provides more disaggregated information than would be available from a macroeconomic model.

1.2 Input-Output Multipliers⁴

A multiplier in I-O measures the response of the economy to a one unit change in final demand for the output of a particular sector. Using the figures in Table 2 it is seen that the output response of the economy to a one dollar change in final demand for the output of sector 1 is 1.509 (measured as dollars of output). Thus the output multiplier for sector 1 is said to be 1.509. The output multiplier for sector 2 is 1.772, and for sector 3 it is 1.346. In using I-O multipliers for economic analysis, the assumptions of homogeneity and proportionality are involved. "Homogeneity" means that every \$1 change in the final demand for a particular sector has the same input requirements. This assumption could be violated if, for example, the sector was "Textiles", and the final demand change being modelled was for cotton textiles only. The sector would include cotton, woollen, synthetic and other textiles, each of which have different input requirements.

The "proportionality" assumption refers to the fact that as each sector changes its output, it is assumed to change its input purchases in proportion to the output change, the proportions being the a_{ij} coefficients in the input column for the particular sector⁵. This assumption would be violated if, for example, as a particular sector expands its output it enjoys economies in the use of inputs.

Closure of the model with respect to Households has the effect of increasing the output multipliers by the inclusion of the effect of induced consumption expenditure. The assumptions of homogeneity and proportionality now apply to Households as a sector as well as to the other sectors.

⁴ This section contains a very brief outline of the notion of I-O multipliers. For a more detailed discussion see West and Jensen (1980).

⁵ More details on these assumptions are contained in United Nations Statistical Office (1973, p. 20).

In addition to output multipliers, I-O often defines income multipliers and employment multipliers. An income multiplier may be obtained from the data in Table 2 above by multiplying each element in a column of the Table by the appropriate Household income coefficient. For example, an income multiplier (I) for sector 1 would be given by:

$$(6) I_1 = \sum_{i=1}^3 h_i z_{i1}$$

where z_{i1} refers to the elements in column 1 of the Leontief inverse, and h_i is the income coefficient of sector i . The h_i are calculated by H_i/X_i where H_i is the total Household income in sector i (from the transactions table), and X_i is the total output of sector i .

The assumption made here is that every dollar of output from sector i results in a payment of income to Households (in the form of wages) of h_i . An employment multiplier may be similarly defined where the h_i coefficient in equation (6) is replaced by an employment coefficient e_i where it is assumed that every dollar of output from sector i results in employment of e_i units of labour being required in that sector.

As with output multipliers, the value of income and employment multipliers is increased by closing the model with respect to Households.

1.3 Usefulness and Limitations of the Technique

This section contains a general review of the usefulness of I-O; specific Australian applications are discussed in sections that follow. As has been pointed out above, the technique has advantages over partial industry modelling and over aggregate macro models in terms of the comprehensiveness of its approach and the detailed information that it can provide. A basic application arises from the information provided in the transactions table on the structure of the economy. This is particularly relevant at the regional level where knowledge of the structure of a regional economy is important for economic policy makers at the State and sub-State level.

In recent years the technique has become very popular in impact analysis, where policy makers are interested to know the impacts on an economy of a particular industry, activity, policy stimulus, etc. The first hurdle to be overcome in such applications is to translate the impacting variable(s) into a form where they represent changes to final demand. Once this has been done, the I-O multipliers of the previous section may be used to measure the effects on output, income and employment in the economy being studied. Because the impact information is available in disaggregated, as well as total form, policy makers are provided with information on which industries or sectors are impacted and by how much. If effected industries are likely to experience difficulties in accommodating the impacts, appropriate remedial action by policy makers is indicated.

In many Australian regional impact studies, the employment consequences of resource development projects have been measured by the I-O technique. By doing the appropriate demographic sums, Governments can assess the likely population effects on the region and can therefore better plan for social infrastructure requirements such as housing, roads, schools, etc.

Careful attention should be paid to ensuring that the homogeneity and proportionality assumptions are not seriously violated when using I-O for impact analysis. A study to measure the impacts of expanded beef exports, for example, would be invalid if it used the I-O multipliers for a sector which included both sheep and cattle. Similarly, a regional study of the effects of a very large resource project may be invalid if the project is so large as to seriously alter the economic structure of the region.

In addition to these problems, there is the general problem that the I-O model precludes the possibility of substitution between intermediate inputs, and between intermediate and primary inputs. Such substitutions may arise in practice because of:

- (i) technological changes. These may be particularly important where the basic I-O data was compiled for a period which is distant in time from the period being studied.
- (ii) changes in relative prices.

The I-O model is in fact "price-free" in the sense that all supply curves are assumed to be flat. This means that when demand changes, the response is entirely on quantity and not on price. To the extent that there are any constraints operating on supply adjustment, this assumption is invalid. For an excellent discussion of the types of constraints that may be involved the reader is referred to Parmenter (1982, pp. 71-72).

2. Australian Input-Output History

2.1 National Compilation

The earliest I-O tables for Australia were compiled by Burgess Cameron at the A.N.U. (see Cameron 1957, 1958). Cameron compiled the tables clerically, using commodity flow data collected by the then Commonwealth Bureau of Census and Statistics. Cameron's interest in the technique was not restricted to compilation, as evidenced by his articles on structure (Cameron 1958) and import substitution (Cameron 1964). It is significant that some ten years elapsed between the reference year of Cameron's first table (1946-47) and its year of publication (1957).

The problem of the lag between the reference period and publication continued to be a problem under official endorsement. The Australian Bureau of Statistics (ABS) published its 1958-59 tables in 1964. It subsequently has published tables for 1962-63, 1968-69 and 1974-75 in 1973, 1977 and 1980 respectively. Thus Australia's central statistical office has managed to publish only four I-O tables in almost 25 years with an average lag of over 7 years. All but the 1974-75 tables were compiled clerically from commodity flow data. In an attempt to reduce the lag time, the latter were estimated using a combination of clerical compilation and RAS projection of coefficients from the 1968-69

table⁶. The Bureau is planning to continue to use a combination of RAS and its own data sources and hopes to further reduce the lag, with the ultimate aim being the publication of an annual series of national tables⁷.

2.2 National Applications

Apart from Cameron's efforts, the Australian academic community tended to ignore I-O as a research technique through the 1950s and to some extent the 1960s. The early tables had a tendency to be regarded as ends in themselves, illustrating structural characteristics of the economy and deficiencies in ABS data gathering efforts. The general equilibrium nature of the technique and its emphasis on linkages between sectors of the economy were largely ignored until the 1960s when the Tariff Board (now the Industries Assistance Commission or IAC) recognised its usefulness in analysing the effects that tariff protection for one sector had on other sectors of the economy. This interest blossomed when the IAC established the IMPACT Project.

The IMPACT Project encompasses four models of Australian economic endeavour:

- (i) ORANI—a short term, general equilibrium model,
- (ii) MACRO—a short term model of macroeconomic aggregates,
- (iii) SNAPSHOT—a long term, programming-type general equilibrium model, and
- (iv) BACHUROO—a demographic/labour model.

Of these, both ORANI and SNAPSHOT are what is termed “input-output based”. ORANI is a model of the non-linear Johansen type (see Johansen 1960) which has been linearised in percentage change form, and which uses national I-O data to provide estimates of various parameters. SNAPSHOT is an I-O based linear programming model.⁸ Thus although they are not Leontief-type I-O models, their emphasis on sectoral linkages and their general equilibrium nature imbue them with the same philosophy.

ORANI has been used for numerous simulation exercises relating to the Australian economy. The effects of such things as tariff changes, oil price rises, wage changes and mineral export booms have been modelled. Many of these are to be found in Dixon, Powell and Parmenter (1979). SNAPSHOT has been less used, but its use in modelling the effects of technical change is to be found in Dixon and Vincent (1980).

⁶ The RAS technique was developed by Richard Stone and others (1963). It is a bi-proportional matrix technique for projecting I-O tables through time. A concise description of the technique is given in Appendix B of Australian Bureau of Statistics (1981).

⁷ At the time of writing, the Bureau expected to publish the 1977–78 tables at the end of 1982. These tables are intended to be the first of the annual series.

⁸ Early work in Australia using this type of model was performed by Evans (1972) and Klijn (1974).

In the late 1960s and early 1970s, Australian interest in I-O as a technique⁹ began to grow. Much of the work was being done by individuals in isolation and, as evidenced in the next two sections, a good deal of it was of a regional rather than national nature.¹⁰

The paper by Preston (1969) was something of a landmark. It not only discussed some of the conceptual problems that arose from different valuation procedures in the compilation of I-O tables, but also used the tables for analytical purposes. The structure of the various countries of the Economic Commission for Asia and the Far East was analysed with particular attention being paid to the role of the agricultural sector.

Douglas (1973) also had an agricultural bias in using the ABS 1962-63 tables to calculate labour multipliers in various land intensive sectors. He expanded the traditional employment multipliers by including labour demand created by a sector's sales, as well as by its purchases. As such, it was really a special application of the Rasmussen (1952) technique of forward and backward linkage analysis. This technique was also used by Hazari and Kingma (1976) in comparing the relative roles of the agricultural sectors in Australia and New Zealand.

The backward linkage of a particular sector is a measure of the extent to which it needs to purchase inputs from other sectors in order to satisfy the final demands for its output. The forward linkage of a particular sector measures the extent to which it supplies other sectors with their inputs. Since the Leontief I-O system is demand driven (by the elements of final demand), a sector with a strong forward linkage is only important because of the demands made upon it by other sectors. Therefore, it would appear to be inappropriate to conclude that a sector was important because of a strong forward linkage.

In the late 1970s, some national applications of a non-agricultural nature appeared. Aislabie and Ip (1977) used the 1962-63 tables in conjunction with employment data to estimate the direct and indirect labour requirements, by skill type and sector, of satisfying Australia's final demand vector. Karunaratne (1979) examined the trade-offs between energy use, environmental quality, and employment growth using the 1974-75 tables. The notion was expanded by James (1980) who, in suggesting a model of energy use by type of energy and by sector, ran up against the perennial problem of insufficient data.

In a novel application, the Bureau of Industry Economics (1979) gave official status to the technique when it used the 1968-69 tables to compute the economic impact on the Australian economy of expenditure by tourists from overseas. The usefulness of the technique in assessing the importance of tourism

⁹ This is distinct from interest in the national tables as data sources for Johansen type models.

¹⁰ There was a "conventional wisdom" in Canberra public service circles in the 1960's that input-output was viewed with suspicion by senior Treasury officials, who regarded all modelling and modellers as possible threats. This attitude was supposedly responsible for the poor funding and low staffing of ABS input-output branch and may have contributed to the lack of enthusiasm for the technique in the academic community. The restrictive assumptions of the technique may have also contributed to this lack of acceptance.

has led to a number of regional studies being commenced in this area¹¹. Impact analysis is in fact a popular area for I-O because many economic stimuli can be readily expressed in terms of changes to final demand. Hence Mules (1982) used the projected construction demands for the Alice Springs to Darwin railway to measure both the national and regional impacts of the construction expenditure. Given the "final demand" nature of construction expenditure, it is somewhat surprising that to the author's knowledge other construction projects in Australia have not had their impacts measured using I-O.

An interesting application that was published in the Australian literature, but actually related to the U.K. and Papua New Guinea I-O tables, was Kennedy and Thirlwall (1979). They make the point that the direct and indirect import propensity is different for each category of final demand expenditure. Only an I-O approach can identify these differences, and an aggregated approach which relates imports to total final expenditure is liable to be in serious error for specific expenditure stimuli.

2.3 Regional Compilation

While I-O efforts of a national nature languished during the 1960s, interest in regional I-O analysis began to grow. Parker (1965) was the first I-O table for a State of Australia. Parker's table was for Western Australia, where the existence of interstate trade data made life easier at the same time as the smallness of the economy made confidentiality problems greater. Parker's approach was basically clerical, using official commodity flow data augmented by surveying firms and organisations. The present author's South Australian table (Mules 1967) was the first in Australia to be compiled using a non-survey method. The method involved "regionalising" the national I-O coefficients to make them reflect South Australian conditions. Employment data were used to adjust national coefficients and the resulting table was then balanced to make it conform to known aggregates relating to the South Australian economy.

Table 3: Australian Regional Input-Output Tables

Author	Region	Base year	Number of sectors	Construction method
M. Parker (1965)	Western Australia	1953-54	30	survey
T. Mules (1967)	South Australia	1958-59	29	non-survey
G. McCalden (1969)	Town of Muswellbrook, N.S.W.	..	21	survey
C. Reynolds (1971)	Town of Gatton, Qld
R. Percival (1972)	City of Tamworth, N.S.W.
G. Dawe <i>et al</i> (1974)	Town of Cooroy, Qld	1972-73	12	survey

¹¹ In assessing the costs and benefits of tourist promotion schemes and the provision of social infrastructure to support tourism, it is necessary for policy makers to be able to quantify the economic effects of expenditure by tourists. The output, income and employment generated by such expenditure is usually regarded by policymakers as an economic benefit.

Table 3: *Australian Regional Input-Output Tables—continued*

Author	Region	Base year	Number of sectors	Construction method
R. Jensen (1976)	Central Queensland (3 statistical divs)	1965-66	26	survey
T. Mandeville R. Powell (1978)	City of Dubbo, N.S.W. and surrounding shires (Central Macquarie statistical sub-div)	1968-69	25	survey
B. Harvey (1976)	Town of Bourke, N.S.W. and surrounding shire	1967-68 1969-70	13	survey
G. Edwards (1977)	Tasmania	1968-69	45	survey
D. McGaurr (1976)	City of Toowoomba, Qld	1970-71	15	survey
S. Huxley (1973)	Queensland (interregional)	1970-71	3 sectors 11 regions	survey
J. Dickinson (1981)	Northern region of Queensland	1970-71 1970-72 1972-73	42	survey
R. Jensen T. Mandeville N. Karunaratne (1979)	Queensland and its ten statistical divisions.	1973-74	11, 19, 36	GRIT
M. Butterfield (1979)	South Australia	1974-75	29	non-survey
R. Higgins (1979)	Jemalong Shire, N.S.W.	1968-69	25	survey plus non-survey
G. West J. Wilkinson R. Jensen (1979)	South Australia and five regions	1976-77	11, 19, 36	GRIT
G. West J. Wilkinson R. Jensen (1980)	Northern Territory and its regions	1976-77	11, 16	GRIT
J. Morison T. Mules (1981)	Revision of N.T. Tables	1976-77	11, 16	GRIT
W.A. Department of Resources Development (1980)	Western Australia and regions	1975-76	17	GRIT
R. Powell <i>et al.</i> (1981)	Victoria and regions	1976-77	11, 19, 36	GRIT

A summary of the known Australian regional I-O compilations is provided in Table 3. The table reveals a spate of survey-based tables during the early to mid 1970s followed by an explosion of interest in the GRIT technique during the late 1970s. GRIT (Generation of Regional Input-Output Tables) is a formalised non-survey method of compilation with facility for the user to insert survey data at any stage of the compilation procedure. It is therefore often referred to as a "hybrid" of survey and non-survey approaches to compilation. It was developed in the Department of Economics at the University of Queensland, largely in response to a State Government request for a planning tool that was both timely and inexpensive.

Prior to the development of GRIT, there was some controversy over the relative merits of survey and non-survey tables. Miernyk (1976) argued that accuracy could only be achieved with a survey-based table, while Jensen (1980)

suggested that the level and type of accuracy achievable with survey-based tables might not justify the expense and time taken to prepare them. GRIT was intended as a compromise between these two schools of thought and, as can be seen from Table 3, has found ready acceptance amongst State Administrators in Australia who have sponsored all State tables but the Victorian ones. New South Wales is conspicuously absent from the list of State tables in Table 3, but the paper by Phibbs in Twohill and Sheehan (1981) is evidence of an awakening of interest in that State.

This section on compilation of regional I-O tables would not be complete without reference to the paper by Martin (1972) which used the RAS technique (see footnote 6) to project Parker's 1958-59 table for Western Australia forward to 1965-66. The paper was the first application of the RAS technique in Australia, and until ABS (1979) and Butterfield and Mules (1980), was the only one. It is significant that this pioneering piece of work was done at the regional level. It is also significant that the type of information which it provided was ignored by the Western Australian authorities until the resources boom of the 1970s caused a clamour for a GRIT-type I-O table.

2.4 Regional Applications

The early regional I-O tables in Australia featured applications that were distinctly agricultural in their orientation. Parker (1965), Parker and Yeow (1966), and Mules (1967) were all concerned with the extent to which exports of rural products were supportive of regional manufacturing industries via production linkages. Powell and Mandeville (1978) and Harvey (1976) showed that fluctuations in rural fortunes led to fluctuations in activity in the non-rural part of the region of interest, the essential interest being the *instability* of support rather than its mean level.

The study of Mandeville and Jensen (1978) of the economic impacts of industrial and resource development at Gladstone in Queensland was a major breakaway from the earlier agricultural emphasis. This study marked the beginning of the success story of the GRIT technique in generating tables for use in resource development impact studies and coincided with Australia's mineral boom of the late 1970s. Western Australia followed with Department of Resources Development (1980) which assessed the impacts of the Wagerup and Worsley alumina developments. The Iron Triangle Study Group (1982) used the South Australian GRIT tables for assessing the employment generating prospects of various resource developments likely to affect the central part of the State, while Morison and Mules (1981) consisted of a similar application in the Northern Territory.

The use of regional I-O tables in assessing the multiplier effects of large resource projects can be criticised on a number of grounds:

- (i) the linearity assumption of the model is severely tested by the sheer size of the projects;
- (ii) the models contain no price effects or balance of payments effects. All resources are assumed to be in perfectly elastic supply and no shortages are envisaged. Shortages of skilled labour in particular regions is a known aspect of the resources boom that is ignored by the model;

- (iii) the models are only partial in that they ignore feedback effects arising from linkages between regions¹²;
- (iv) the "adding up" problem has not been examined, i.e. when all the individual, partial effects in each State are added together, do they constitute a total which is inconsistent with national possibilities?

Research is under way which is aimed at overcoming a number of these problems¹³. In the meantime, planners and administrators find that, warts and all, the regional I-O model is the best that is available when it comes to providing information for infrastructure planning for the resource projects.

As has been pointed out in section 1.3 above, policy makers have been able to use the (I-O estimated) employment impacts of the resource projects to obtain estimates of the social infrastructure requirements of the associated regional population changes. Despite the limitations of the technique, its advantages of timeliness, relatively low cost, and comprehensiveness have been an attraction to policy makers seeking quantitative information on the projects' impacts. This is not to deny that other approaches (e.g. the use of ORANI in regional mode) might not provide superior measures of the impacts. However, it would appear that policy makers feel that the additional costs associated with more sophisticated approaches is not justified by the superior accuracy that might be obtained.

The GRIT regional tables have been used outside of the resources area for a number of novel applications. Morison and Jensen (1980) assessed the impacts of an ethanol fuel plant on the regions and State of Queensland, while Mules (1980, 1981) used the tables to model the effects of State Government expenditure changes on the State economies of South Australia and the Northern Territory. A. D. Cameron (1980) identified the "information content" of the various I-O sectors in Queensland and amalgamated them to form an information sector, while Driml (1980) assessed the economic effects of expenditure by recreational fishermen in the Capricornia section of the Great Barrier Reef Marine Park. Powell *et. al* (1981) attempted to measure the significance of the tobacco industry to the Victorian and Australian economies, and Hughes (1979) examined the pollution/output trade-offs in the 36 sector Moreton region of Queensland.

An interesting and unusual recent application of a non-GRIT regional table is to be found in Higgins and Robinson (1981). A regional I-O table was compiled for the Forbes/Jemalong region in New South Wales using a combination of survey material, and coefficients "borrowed" from other regional tables. The tables were then used to model the effects of a major flood in the

¹² A case study by Schreiner and Chang (1980) for Oklahoma in the U.S. shows that such effects can be up to 35 per cent of total output effects.

¹³ In particular, the problem of feedback effects is being tackled by the development of interregional I-O tables which measure linkages between regions as well as between industries. This development is currently taking place in two locations in Australia:

- (i) The Department of Economics at the University of Queensland under the supervision of Rod Jensen.
- (ii) The CSIRO Division of Building Research in Melbourne under the supervision of David Batten.

region. The initial impact of the flood was described in terms of lost production and lost incomes to primary producers. The multiplier effects on the region of the consequent reduction in primary producers' expenditure were modelled, as was the effect of expenditure on repairs to buildings, fences, roads, etc. In addition to its novel subject, this study was significant in that it revived the rural sector as a fertile field for I-O applications.

3. Input-Output and the Agricultural Sectors

As has already been noted an agricultural bias was a common thread running through early I-O efforts in Australia. In many ways this is a surprising characteristic, because the agricultural sectors in Australia typically do not satisfy the Leontief assumption of a linear combination of inputs in fixed proportions, giving rise to a single output. The typical Australian farm is a multi-product enterprise with considerable scope for substitution between both outputs and inputs. This feature has been recognised by the IMPACT Project team, and the ORANI model treats agriculture on a regional-climatic rather than product basis, see for example Vincent, Dixon and Powell (1980). Despite the lack of such a facility in a normal Leontief I-O system, agricultural applications continue to be popular, both in Australia and overseas¹⁴.

3.1 Some Overseas Applications¹⁵

Many agricultural applications of I-O involve measuring the effects on the non-farm sector of various impacts in the farm sector. An exception to this was O'Connor (1969-70) who looked at the effects that different rural subsidies would have on farm incomes in Ireland. A popular application in the U.S.A. has been in measuring the impacts of various land use developments. George Goldman of the University of California, Berkeley has found this area to be a fertile field at the County level in California. A full list of Goldman's work is beyond the scope of this paper. However, Goldman and Strong (1977) is a good example, while a full list may be found in the reference to Johnson (1979).

A more sophisticated version of the same type of application is found in Tung, MacMillan and Framingham (1976). They develop a variable coefficient, general equilibrium model using I-O coefficients as a basis. The model is used to measure the impacts of programs such as drainage, land clearing, infrastructure development for three different agricultural activities in the Interlake region of Canada. In a similar vein was the study by Bell and Hazell (1980) of the regional effects of an irrigation project in Malaysia. Here the emphasis was on the effects on export versus non-export industries, reflecting the importance of balance of payments considerations.

¹⁴ The regional nature of many agricultural applications increases the chances of the Leontief assumptions being met. For example, wheat production in a given region of New South Wales is more likely to be characterised by a Leontief production function than wheat production in the whole of Australia.

¹⁵ This Section is not intended to be an exhaustive survey of the overseas literature, but rather an indication of some of the directions that have been taken.

The role of the agricultural sector in developed versus undeveloped economies was the subject of Preston (1969) for the ECAFE countries and was also dealt with in more detail by Parker (1974) for Papua New Guinea, and by Alaudin and Mules (1980) for Bangladesh. The agricultural sectors in undeveloped countries are found to be characterised by a large element of "inwardness" in their use of inputs. They therefore provide little stimulus for growth of other sectors, in comparison with the stimulus given by the high level of purchased agricultural inputs in developed countries.

The study of non-rural and regional effects of rural decline was an application by the United States Department of Agriculture (1969) in North Carolina. This study also used the technique for identifying strategies for replacing rural sectors as key local sectors. Some of the more unusual other overseas applications have been:

- (1) Little and Doeksen (1968), which concentrated on the import leakage from expanded rural output in Oklahoma.
- (2) Simpson and Adams (1975), which suggested disaggregating agricultural sectors into "product lines". They focussed on beef exports from Argentina, Brazil, Paraguay and Uruguay. Their finding was that canned and cooked/frozen beef exports had higher multiplier effects than other lines of exported beef.
- (3) Schreiner and Chang (1980), which studied the feed-back effects from interregional linkages in Oklahoma, using rural output as the exogenously determined "driving mechanism". As has already been noted, they found that up to 35 percent of the effects of a non-rural sector's output was attributable to these interregional effects.

3.2 Australian Agricultural Applications

The agricultural content of early I-O endeavours in Australia has already been remarked upon. Perhaps the earliest of these arose from Parker's Western Australia study and is to be found in Parker and Yeow (1966). This study projected changes in Western Australia's rural exports to 1970, and along with some projected changes in I-O structure, measured the impacts on the non-rural sectors. The present author's (Mules 1967) study measured the amount of manufacturing employment in South Australia that was attributable to indirect demand resulting from wool exports from the State.

A number of Australian studies have measured the general level of "importance" of particular primary activities to the rest of the economy. Douglas and Reilly (1978) estimated the national impacts of the central Queensland forestry industry. Driml (1980) concentrated on the regional multiplier effects of recreational fishing, and Powell *et al* (1980) took on the anti-smoking lobby by calculating the national economic impacts of the tobacco industry.¹⁶ The forestry sector has also been the focus of a number of internal I-O studies carried out within the Victorian Public Service, none of which have been published. They are summarised briefly in Lodge (1981, pp. 33-41).

¹⁶ This study considered processing, manufacturing and distribution of end product as well as tobacco growing. To be fair to the authors of this study, they do point out in their preface that their analysis is partial in the sense that social and health aspects of the industry are not considered.

The traditional way of measuring the importance of a particular sector (say, sector i) in an I-O framework is to use the Leontief inverse to calculate the impetus given to all other sectors from the amount of sector i 's final demand. The implication is that if sector i 's final demand were to fall to zero, output in all other sectors would fall by the amount so calculated as a consequence. This is true, but if sector i were to cease to exist, not only would sales to final demand be zero, so also would its intermediate sales to other sectors. These intermediate requirements would have to be imported and this import replacement role that sector i performs should be regarded as an additional benefit of sector i 's existence. For many rural sectors this may not be an issue since a large proportion of the output is sold to final demand (export and consumption).

The structural characteristic of Australian agriculture in the national economy has been the subject of Preston (1969) and Hazari and Kingma (1976). Preston studied the interdependence of agriculture with the rest of the economy and found that, in developed countries such as Australia, Japan and New Zealand, the agricultural sectors exhibited a higher level of interdependence than was evident in less developed economies such as India, Philippines, Sri Lanka and Malaysia. Hazari and Kingma took the interdependence notion further by calculating linkage parameters for all sectors in Australia and New Zealand. They found that although the primary sectors were consistent foreign exchange earners in both countries, they did not in general have as high a linkage effect as did manufacturing sectors. They concluded that a strong export performance by a sector was not necessarily indicative that that sector was a focal point for economic growth.

Structural considerations at the regional level were the interest of Jensen and Powell (1980). Using the GRIT tables for the ten regions of Queensland, they compared the sales and purchase patterns between regions of two broadly defined rural sectors, namely "Animal Industries" and "Other Rural Industries." The paper is a good example of the large amount of descriptive information that can be obtained from regional I-O tables.

Powell and Mandeville (1978) were also concerned with the linkage between rural and non-rural sectors. Their study of a statistical division in the wheat/sheep zone of New South Wales found that instability in rural incomes was readily transmitted to the urban sectors of the region via I-O linkages. Instability was also the focus of Harvey's (1976) study of the Bourke regional economy. The wool price drop of 1970-71 was modelled in terms of reduced woolgrower incomes and expenditure and the impacts that this had on the town of Bourke.

The above types of regional rural impact analysis have tended to be a one way street in Australia, with the interest always being on the impacts on the non-rural sectors. The Higgins and Robinson (1981) analysis of the effects of flood on a rural region in New South Wales, novel though it was an application of I-O, concentrated attention on impacts on the non-rural or urban parts of the region. Beesley's (1979) study of land development policy measures in the Bowen region of Queensland had a similar emphasis, though the interest was in general regional stability.

The impact of national or even regional changes on the rural sectors themselves has tended to be ignored by traditional I-O studies. However, the I-O based ORANI model has been used in some simulations where primary interest is in impact on the rural sectors. Vincent, Dixon, Parmenter and Sams (1979) paid attention to the effect of oil price rises on the Australian rural sectors. The main losers consequent upon a 40 per cent rise in crude oil prices were the

sectors Northern Beef, Pastoral Zone, Wheat/Sheep Zone, Forestry and Fishing. The Food Manufacturing sector was also a significant loser. Overall, farm income was projected to decline by from 6 to 8 per cent.

Parmenter, Sams and Vincent (1981) used ORANI to project the effects on output, prices and incomes of a home consumption price scheme for wheat. They found that the winners were Wheat/Sheep Zone, Pastoral Zone, Northern Beef, Milk Cattle and Pigs, all of which have some capacity to produce wheat. Losers were Other Farming Export (mainly sugar), Mining, and Processed Foods. Mining is a loser because its export orientation means that it cannot pass on the cost increases that arise from the home consumption price scheme. Not surprisingly, the Agricultural Machinery and Chemical Fertilisers sector are amongst manufacturing sectors which gain from the boost given to wheat growing by the scheme.

The above applications of ORANI have been specifically rural in emphasis. However, every ORANI simulation produces projections for the rural sectors of the economy. Some of the more interesting are the effects of tariff changes, exchange rate variations and mineral booms on the Australian rural sectors. These are reported in Dixon, Powell and Parmenter (1979). What emerges as a general picture is that the ORANI model is essentially driven by its international trading sectors, i.e. export (rural and mineral), and import competing sectors. These sectors are essentially "price takers" and are unable to pass on cost increases to other sectors of the domestic economy. They therefore emerge as net gainers in any deflationary policy and net losers in any inflationary policy.

4. Current Trends

The division of labour in rural I-O studies seems to have been that impacts of the rural sectors on non-rural sectors are the province of traditional I-O, while impacts on the rural sectors of external events are the province of the ORANI type I-O based model. This is probably as it should be, since the latter type of model is better equipped to handle price and substitution effects arising from national and international events. The former is better equipped to handle specific events arising at the regional level, particularly the sub-State level.

It is imperative for both avenues of work that the ABS continue with its program aimed at eventually producing annual national tables. It is presumed that this program will reduce the lag between reference period and publication date. This should help to remove the fear that analysis may be in error because of obsolete data. In addition, ABS should be encouraged to consider expanding its data collection in the regional area and in particular into the areas of labour and capital usage by industries. Regional details of employment in many tertiary sectors are only available from the population census. Where regions are experiencing rapid change, this information needs to be collected and published more frequently¹⁷.

¹⁷ Employment effects in impact studies are often observed to be heavily concentrated in tertiary areas of the economy such as Wholesale and Retail Trade, Public Administration, and Community Services. The data upon which such estimates are partly based is often a five year old census of wholesale and retail trade or a four year old population census.

One way of achieving more frequent data collections in these areas without the cost of a complete census is by use of sample survey. It is felt by this writer that the benefits in terms of up to date information would outweigh any possible disadvantages in the form of sampling errors. The ABS has considerable sampling expertise and it would seem to be within their capacity to keep such sampling errors within acceptable limits.

In addition, regional data on trade flows and population movements could be collected on a survey basis and would provide valuable information for the compilation of interregional tables. The research led by Rod Jensen in the Department of Economics at the University of Queensland is currently attempting to develop interregional tables for the ten regions of Queensland, while Batten and Tremelling (1980) have attempted to develop interregional links between the State of Victoria and the rest of Australia. These efforts, along with Liew's (1980) Australian States study, suggest that the interregional approach is gathering momentum. If the data limitation problems can be solved, or at least reduced significantly, the scope for regional rural applications will be greatly increased.

A popular trend overseas recently has been towards demo-economic models which attempt to combine the economic content of an I-O model with demographic and labour equations. These models allow projections to be made of population movements between regions and how these interact with regional economic events. Ledent (1978) and Ledent and Gordon (1981) are examples of this type of work. Scope would appear to exist for work in this area in Australia where rural decline in some regions, declining manufacturing employment in others, and expansion due to resource developments in others have important consequences for population movements and associated provision of social infrastructure. Lack of data may impede the development of such work in Australia and again the ABS should be called upon to expand its data collection in the area of inter-Censal population movements.

In conclusion, if Australians were slow to accept I-O as a technique initially, the explosion of interest in the 1970s has more than compensated for this. Awareness and use of the technique is now widespread throughout the academic community and at all levels of Government. Adoption by public administrators has not been blindly uncritical, however, and a healthy degree of scepticism has maintained the pressure for better data and better models. This pressure may result in more use being made of ORANI-type general equilibrium models in future. This is particularly likely for large impact studies where price effects and balance of payments effects need to be taken into account. The future for the simple I-O study may then be restricted to small regional issues where the cost of using the larger models is not justified by their advantages.

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