Australian Government
Productivity Commission

On input-output tables: uses and abuses

Productivity Commission
Staff Research Note

September 2013

Paul Gretton

ISBN 978-1-74037-452-1

This publication is available from the Productivity Commission website at www.pc.gov.au. If you require part or all of this publication in a different format, please contact Media and Publications.

Publications enquiries:
Media and Publications
Productivity Commission
Locked Bag 2 Collins Street East
Melbourne VIC 8003

Tel: (03) 9653 2244
Fax: (03) 9653 2303
Email: maps@pc.gov.au

General enquiries:
Tel: (03) 9653 2100 or (02) 6240 3200

An appropriate citation for this paper is:

Gretton, P. 2013 *On input-output tables: uses and abuses*, Staff Research Note, Productivity Commission, Canberra.

The Productivity Commission

The Productivity Commission is the Australian Government's independent research and advisory body on a range of economic, social and environmental issues affecting the welfare of Australians. Its role, expressed most simply, is to help governments make better policies, in the long term interest of the Australian community.

The Commission's independence is underpinned by an Act of Parliament. Its processes and outputs are open to public scrutiny and are driven by concern for the wellbeing of the community as a whole.

Further information on the Productivity Commission can be obtained from the Commission's website (www.pc.gov.au) or by contacting Media and Publications on (03) 9653 2244 or email: maps@pc.gov.au

On input-output tables: uses and abuses*

This staff research note describes the uses and abuses of input-output tables, with the aim of improving future utility of what is an important but sometimes misused resource.

In doing so, the note examines a number of novel approaches to effective use and some examples of abuse.

Novel uses include:

- an environment-economic input-output framework;
- analysis of the composition of exports; and
- foreign value-added levels in nations' exports.

Abuse primarily relates to overstating the economic importance of specific sectoral or regional activities. It is likely that if all such analyses were to be aggregated, they would sum to much more than the total for the Australian economy. Claims that jobs 'gained' directly from the cause being promoted will lead to cascading gains in the wider economy often fail to give any consideration to the restrictive nature of the assumptions required for input-output multiplier exercises to be valid. In particular, these applications fail to consider the opportunity cost of both spending measures and alternate uses of resources, and may misinform policy-makers.

Input-output data and tables on which multipliers are based may be extremely useful in economic analysis. They can provide valuable information about the structure of economies that is not available from other frameworks. Used appropriately, input-output tables provide a powerful tool for reporting and analysing the industrial structure of an economy. They also form the foundations for constructing a range of economic models which, with due attention to their underpinning assumptions, can be used to more properly assess the impacts of policy changes.

* This note was prepared with research assistance from John Papadimitriou, Daniel McDonald and Christine McDaniel. The author is grateful to Andrew Cadogan-Cowper (ABS) and Gerard Kelly (RBA) and to colleagues at the Productivity Commission for their support and feedback on drafts.

1 What are input-output tables and input-output multipliers?

Most sectors of a modern economy are highly interdependent. Individual industries employ labour and capital, use resources, and purchase inputs from other industries and overseas. They sell their products to other producers and to consumers, both domestically and internationally. These economic flows are recorded in input-output tables, typically according to detailed product and industry classifications. Input-output tables describe production and consumption interdependencies at the regional, national and, more recently, global level (box 1).

Australia has a long history of compiling and using input-output tables (Gretton 2005). The first full compilation of input-output tables by the Australian Bureau of Statistics (ABS) was for the reference year 1962-63. The latest tables are for the year 2009-10 (ABS 2013a). Most economies now have input-output tables and these have been brought together in regional and global frameworks (see IDE-JETRO 2013, GTAP 2013, OECD 2012, WIOD 2013).

Input-output multipliers — assumptions and limitations

The sequence of transactions captured in input-output multiplier analysis

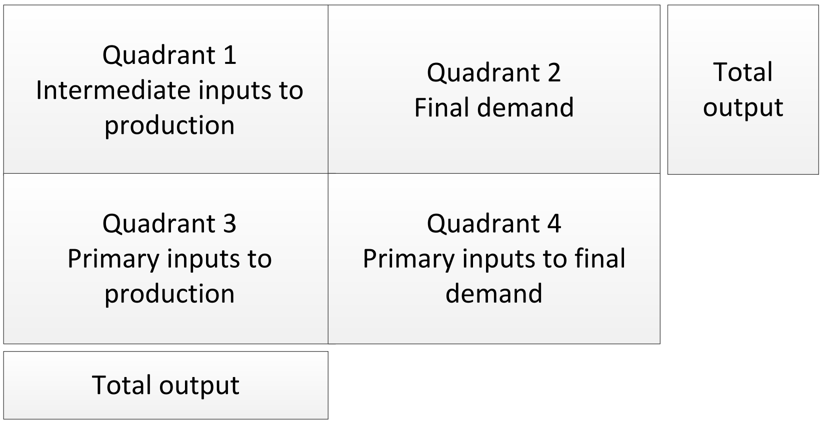
Input-output tables can be used to compute output, employment and income multipliers. These multipliers take account of one form of interdependence between industries — that relating to the supply and use of products. The numbers add up the direct and indirect impacts of a change in final output of a designated industry on economic activity and employment across all industries in an economy.[1] As input-output tables and multipliers focus on the supply and use of products, they have a distinct micro focus. This feature distinguishes them from other multipliers in economics, most notably the fiscal (or Keynesian) multipliers and money multipliers which focus on macroeconomic and monetary relationships, respectively.

[1] Industries are also linked through spillovers such as through the embodiment of knowledge and learning in inputs used across industries, dissemination of best practice processes and demonstration effects, as well as through influences on the operating environment of businesses and the community more generally. These linkages are more difficult to identify and quantify than inter-industry linkages.

Box 1 **The input-output system**

An input-output table is represented, at its simplest, by four quadrants (box figure).

- Total output for an industry can be found by adding its sales of goods or services for intermediate use by other industries and for final use, including exports (that is, across quadrants 1 and 2).
- Total output of that industry can also be found by adding its own use of goods and services (its intermediate inputs) and primary inputs of labour and capital to production (that is, down quadrants 1 and 3).



The centre-piece of the input-output system is the industry by industry intermediate inputs matrix (Quadrant 1). This matrix defines the two-way links between industries and, through these links, the labour, fixed capital and natural resource requirements of final demand. Input-output methods use this information to define a two-way process linking the demand for goods and services to the generation of value added. The system therefore can be interpreted as reflecting the technical relationship between the level of output and the required quantities of inputs, and the balancing of supply and demand for each type of good and service.

Value added for the economy is represented either by the value of final demand for output (consumption plus investment plus exports less imports) or by the value of primary inputs used in that production (labour plus capital income plus rent on natural resources). The value added for any industry is the value of its sales (output) less the value of its intermediate inputs (other industries outputs). Gross domestic product (GDP) adds up value added by industry, not the value of industry outputs or sales.

In practice, there are many subtleties of input-output tables that are not reflected in a stylized representation. These include: the valuation of transactions (as between basic prices and purchases' prices); the treatment of imports (as between the direct allocation of imports to the using industry or final demand); and the treatment of material inputs to commission work, such as oil refining (that is, whether the raw materials are treated as inputs to the manufacturing industry undertaking the commission work or as 'inputs' to the services industry commissioning the work).

By adopting the simplifying assumption that the average relationships between outputs, inputs, income and employment in the input-output table apply at the margin, input-output multipliers have been used to quantify the impact of economic change. Such uses go beyond looking at the measured contribution of an activity and industry to the economy to looking at possible economic impacts of a specified change (or shock) to the status quo, that is, how production may respond to postulated changes in final demand for the output of an industry.

The assumption that average input-output relationships apply to a marginal change is characterized by a number of operating assumptions (box 2).

Box 2 **Simplifying assumptions of input-output multiplier analysis**

The assumption that average input-output relationships apply to a marginal change requires that:

- there is a fixed input structure in each industry, described by fixed technological coefficients;
- all products of an industry are identical or are made in fixed proportions to each other;
- each industry exhibits constant returns to scale in production;
- there is unlimited labour and capital available at fixed prices — so that, any change in the demand for productive factors will not induce any change in their cost; and
- there are no other constraints, such as the balance of payments or the actions of government, on the response of each industry to a stimulus.

Under these assumptions, multiplier analysis can be used to decompose the effects of change according to:

- the *initial* output effect — the change in the production, employment and value added of an industry required to supply an additional unit of final output of that industry;
- the *direct* (or first round) effects — the changes in the output, employment and value added of industries supplying intermediate inputs to the industry in question; and
- the *indirect* (or induced) effects — the changes in the output, employment and value added in all stages of the production chain required to support an additional unit of final output to the industry in question and its suppliers.

The input-output multiplier methodology can also be extended to link changes in value adding income to final demand through the *income-consumption* effect (termed Type 2 multipliers). This effect seeks to measure the change in consumption for all goods and services that arises from an increase in final output from the industry in question.

Limitations of input-output multiplier analysis

After a long history of compiling input-output tables, the ABS published its first input-output multipliers for 1989-90. In that inaugural publication, it noted that the input-output tables underlying multiplier analysis only take account of interdependence between industries through the sales and purchase links and that:

> 3. … Other interdependence such as collective competition for factors of production, changes in commodity prices which induce producers and consumers to alter the mix of their purchases and other constraints which operate on the economy as a whole are not generally taken into account. (ABS, p. 24)

The publication of multipliers was discontinued with the release of the 2001-02 table against the background that:

> …There was considerable debate in the user community as to their suitability for the purposes to which they were most commonly applied, that is, to produce measures of the size and impact of a particular project to support bids for industry assistance of various forms. (ABS 2012, p. 569)

While recognising that ease of use had made input-output multipliers a popular tool for economic impact analysis, the ABS explained that they stopped publishing them because they had a number of inherent limitations and shortcomings for use in impact assessment (ABS 2012, p. 569). These largely reflect the failure of the assumptions in box 2 to hold in practice.

- *Lack of supply-side constraints* — multipliers assume that extra output can be produced in one area of activity without taking away resources from other activities. Actual impacts would be dependent on the availability of appropriate labour and capital and other productive inputs.
- *Fixed prices* — so that effects of relative price changes play no role in the allocation of scarce resources between activities. Actual impacts would be affected by relative price changes due to constraints on the availability of labour, capital and other inputs and policy changes (such as import tariff changes or the impact of competition policy on business costs and prices).
- *Fixed ratios for intermediate inputs to production and outputs from production* — so that changes in production technology and the use of inputs in production play no role in impact assessment. Actual impacts could be affected by changes in production technologies including in the use of domestic and imported inputs and the mix of outputs including in the supply of products to household, investment and export demands.

- *No allowance for households purchasers' marginal responses to change* — so that real budget shares remain unchanged with changes in household income and relative prices. In practice, the level and composition of household purchases would be affected by income and relative price changes.
- *Absence of budget constraints* — so that changes in household or government consumption occur without reducing demand elsewhere. In practice, the level of consumption expenditure by households and government would be budget constrained.

In addition to these limitations, the ABS assesses that regional multipliers simply calculated directly from the national I-O tables are not appropriate for use in economic impact analysis of projects in small regions.

> - … Inter-industry linkages tend to be shallow in small regions since they usually don't have the capacity to produce the wide range of goods used for inputs and consumption, instead importing a large proportion of these goods from other regions. (ABS 2012, p. 569, para. 22.155)

2 Use and abuse of input-output multipliers

Use of multiplier analysis

The conceptual limitations involved with using multiplier analysis have not constrained its widespread use to:

- justify or support calls for injections of taxpayer funding;
- rally against perceived potentially adverse policy decisions; or to
- highlight the broader economy's dependence on particular activities or regions.

Economic commentators and interest groups have all made use of multipliers to estimate or infer the impact of policy decisions on a specific sector or region (box 3).

Box 3 Use of multipliers at national and sub national levels

A consultancy commissioned by pharmaceutical company Merck Sharp and Dohme (MSD) (Australia) to highlight its contribution to the Australian economy.

> Using the multiplier effect, Access Economics estimates that in the year 2000 MSD's expenditure was responsible for creating an additional 4,600 jobs through our supplier relationships, particularly in the Western Sydney region. In addition, our expenditure generated an extra $555 million in gross output and an extra $280 million of value added output in the Australian economy. (MSD 2002, p. 1)

A submission by National Disability Services Australia to recent PC inquiry.

> If just 4 per cent of people currently on the DSP found employment within the community services sector (a relatively low-paying sector and one which has limited flow-on effects), the model predicts the economic impact to be about $5 billion dollars. If, however, these people found employment across all industry sectors (in accordance with the percentage of the workforce working in each major industry sector) the economic impact (the industrial and consumption effects) could be as large as $25 billion. (sub. DR836, pp. 3-4, PC 2011)

An article by Senator Kim Carr to highlight the economic contribution of Australia's motor vehicle manufacturing industry.

> The industry pays the wages for 46,000 Australians directly; and at least 200,000 in related manufacturing and service industries, using the standard international employment multipliers. It takes $1.3 billion in locally manufactured iron and steel, $444 million in polymer products and $157 million in chemicals. It also underpins business of nearly $2 billion for local wholesale trade and uses $1.6 billion of professional, scientific and technical services. (Carr 2012)

A Business Council of Australia study looking at Australia's investment opportunities, risks and barriers, and the indirect benefits from Queensland resources activity.

> … in Queensland, resources sector business supply and employment effects are generating approximately $50.1 billion in Gross State Product — $22.1 billion directly and $28.1 billion in value added effects. The resources sector was found to be responsible for generating approximately 292,000 jobs — including 254,000 indirect jobs. (BCA 2012, p. 9)

Charles Sturt University (CSU) estimated significant flow-on regional economic impacts from its public funding program.

> According to an independent analysis by the Western Research Institute, in 2010 Charles Sturt University contributed $524 million in gross regional product, $331 million in household income and 4,996 full-time equivalent jobs to its rural and regional communities when initial and flow-on expenditures are counted. For every one dollar of Federal Government funding received, Charles Sturt University returns approximately $4.75 to the Australian economy. (CSU 2010)

In contrast to the use of multiplier analysis in support of specific activities, a Victorian academic used the tool to downplay the economic benefits from gambling activities:

> What we know from studies done by the South Australian Centre for Economic Studies last year is that the employment multiplier effects from gambling is about three jobs per $1 million. The employment multiplier effects from restaurants and catering businesses is about 20 jobs per $1 million. So there's certainly a strong argument that the employment and economic benefits of gambling are much less than they would appear. (http://www.abc.net.au/stateline/vic/content/2006/s1908525.htm, 27/4/2007)

Claims by proponents are often couched in terms of the flow-on employment benefits of providing public funding (such as through subsidies or tax breaks) or the potential for extended job losses from industry deregulation and other microeconomic reforms. These claims particularly resonate at times of high unemployment. Indeed, the existence of unemployed resources has been used to challenge the argument that multiplier analysis ignores supply-side constraints (see above). Access Economics, for example, in a consultancy study promoting the benefits of pharmaceutical company Merck Sharp and Dohme Australia said:

> We do note that for most of the past decade the economy has had an unemployment rate above the sustainable long-term level. In other words, surplus resources have been available for considerable periods of time. (MSD 2002, p. 9)

But while it is certainly true that high unemployment has been an episodic feature of Australia's economic history, it can by no means be assumed that the skill and locational profile of the unemployed would align with the specific industry and/or region skill requirements of the target of public funding support, at least in the short term.

Proponents also variously point to output, value added, income, investment and export multipliers that will flow from supportive policy decisions (Banks 2002, p. 9). These arguments are sometimes reinforced by the claim that higher tax revenues from increased corporate and employment activity will offset public funding so that taxpayer support in effect 'pays for itself'.

A hallmark example of the risks of using multiplier analysis to infer the impact of policy change on the fate of an activity or region is provided by the adjustment experience of the Latrobe Valley (part of the Gippsland region of Victoria) following the rationalisation and privatisation of the state-owned electricity generation industry in the early 1990s. In criticising the electricity reform program and its outcomes, the Victorian Council on Social Services cited a study prepared for the Victorian Ministry of Employment and Training (using a survey-based regional input-output database) to argue that every job that was lost in the industry led to the loss of a further 2.6 jobs in the wider regional economy (Carter and Milanese 1983, p. v, PC 2005, p. 110). However, after declining by around 3900 persons (14 per cent) between the Census years 1991 to 1996, employment in the Latrobe Valley (the main centre of electricity generation in the Gippsland region of Victoria) then increased by 1200 persons by the year 2001 and increased by a further 4100 persons by 2011 (ABS Population Census 2001, 2006, 2011). The population of the Latrobe Valley stood at similar levels in 2011 compared to 1991, at 71 and 72 thousand persons, respectively.

In this case, while the multiplier analysis may have been an expression of adjustment pressures, it was not a good indicator of the ultimate prospects of the region. It also did not provide an indication of the considerable regional and national economic benefits of reform of the region's electricity industry (PC 1999 and 2005).

A more contemporary example of the use of multipliers is the analysis by the Australian Government's Department of Resources, Energy and Tourism (RET) used to highlight the broader relative contribution of the tourism sector to Australia's economy.

> Using the Australian Bureau of Statistics' input-output tables, tourism's total output multiplier is valued at 1.91. This means for every dollar tourism earns directly in the Australian economy, it value adds an additional 91 cents to other parts of the economy. At 1.91, tourism's total multiplier is larger than other important industries such as mining (1.67), retail trade (1.80) and education and training (1.38).
>
> Using the same methodology, tourism's total employment multiplier is valued at 11.4 with an indirect employment multiplier value of 4.04.
>
> Using this multiplier, a one per cent increase of tourism direct consumption expenditure of $80 billion ($0.8 billion) generates output outside tourism of $0.7 billion (in nominal terms) and an increase in employment outside tourism of 2,800 persons. (RET 2011, p. 18)

This example serves to highlight another common feature of multiplier use — the application of average relationships between outputs, inputs and employment to a marginal change in demand. In this case, the relative magnitude of the tourism output and employment multipliers is taken to infer the national impact of an increase in tourism consumption expenditure. The analysis does not take account of the availability of scarce labour and resources needed to meet the additional demand or the alternative uses of those resources (that is, their opportunity cost).

The comparison also highlights other possible shortcomings of multiplier analysis.

- The multiplier calculation, as such, does not infer that there is potential additional demand that would engender the scale of additional output implied by the multiplier.
- Tourism is not an industry in the conventional sense and is in fact, defined in the ABS tourism satellite account as an amalgam of other industries including transport, accommodation, food service provision, retail trade, entertainment and education (PC 2003, ABS 2009). Multipliers for a satellite industry such as tourism double count multipliers of component activities.
- Tourism as conventionally defined, includes people travelling for recreation as well as people travelling for business, study, medical treatment and other non-

> leisure activities. Analysis based on the historical composition of a diverse group of expenditure activities, such as tourism, may not provide a meaningful assessment of the possible impacts of likely future changes.

Another perspective on input-output multipliers may be to emphasise the conditions under which input-output analysis may meaningfully indicate the impact of an economic change. For example, Dennis (2012) comments that because of the rigidity of input-output assumptions and the inability of standard multiplier analysis to take into account resource scarcity and the role of relative prices, input-output modelling should only be used to evaluate 'relatively small' changes in the economy. That is, changes where it can be assumed that 'all other things remain equal' (p. 9).

Even when these assumptions are likely to apply, however, it does not imply anything about the desirability or otherwise of the change from an economic perspective or whether there is a case for government intervention to encourage or prevent it from occurring. That is, estimated changes in industry output or employment derived from multiplier analysis cannot be interpreted as necessarily indicating the value of output or the number of jobs in the economy which are dependent on the existence of a particular industry or demand for its output.

Abuses are well recognised

The lack of accounting for the opportunity costs in input-output multiplier analysis has resulted in persistent expressions of concern over many years regarding the applicability of multiplier analysis in a public policy context. As noted, a common focus of the concern is on the use of multipliers to make the case for government intervention (either to preserve prevailing output or employment under threat or to support the set up or expansion of a designated activity).

At a time when structural adjustment was occurring in the Australian economy from reductions in border assistance and industry support, the Industries Assistance Commission (IAC) (a predecessor of the Productivity Commission) in a working paper on the use of input-output analysis and multipliers noted that:

> From time to time participants to IAC inquiries present evidence in support of their arguments which is based on IO tables and analysis...Participants who draw on IO analysis in their submissions often do so:
>
> - to illustrate that the importance of an industry extends beyond its own boundaries, because of sales and purchasing links with other industries; and/or

- to suggest that assistance to the industry should be increased (or maintained) because the industry ‘generates’ additional activity in other parts of the economy. (IAC 1989, p. 1)

While recognising that input-output multipliers have the advantage that they are available to inquiry participants at relatively low cost, the Commission concluded that from the perspective of its inquiry and reporting programs:

> …multipliers are a poor predictive device in many applications. In the context of assessing assistance to industry, how changes translate into changes in demand … is not clear. Also, they often overstate effects on account of the omission of important adjustment mechanisms and constraints. Finally they can mislead policy prescriptions in that they take no account of social costs and benefits. (IAC 1989, p. 18)

Banks (2002) in a speech on interstate bidding wars for major projects drew attention to financial inducements afforded by state governments to attract such projects and, amongst other things, claims of the benefits of success. In this context, he noted that a ‘common claim is that each extra dollar of output generated by the recipient firm generates several more dollars-worth of activity … as the initial expenditure is spent in several subsequent rounds in the local economy’ (p. 7). He observed that while such claims recognised the complex inter-linkages between different parts of the economy, they failed to consider the opportunity costs of the spending. He added that economic benefits of efficient government outlays do not come simply from input-output linkages, but rather from improvements in efficiency and resource allocation that new investments can bring (p. 8).

In a 2002 economic research article on the ‘Use and Abuse of Input-Output Multipliers’ (Western Australian Department of Treasury and Finance 2002), it was noted that ‘so called “multipliers” are often used to illustrate the significance of an industry or activity in the overall economy (p. 19), and that ‘…when it comes to assessing calls for public assistance, it must be recognised that these multipliers do not even ask the “right” question policy makers should be asking themselves’ (p. 19). In the conclusion to the article, while recognising that multipliers can be a useful way of summarising and quantifying inter-linkages, it was noted that ‘…they are more often abused than used correctly’ (p. 50). The Western Australian Treasury also commented that:

> Multipliers are used to suggest that an industry is more valuable to Western Australia than its current size would suggest. …However, multipliers do not provide a measure of net economic benefit of expanding activity in a particular area… It is in assessing claims for government assistance that the potential misuse of multipliers is greatest. (WA Department of Treasury and Finance 2002, p. 19)

The Victorian Auditor-General has referred to the use of input-output multipliers in policy analysis on at least two occasions. On the first occasion in 2002, the use of multipliers to assess the additional employment and economic activity within the local economy from assisted investment was considered, amongst other things. In this context the Auditor-General noted that 'The magic of multipliers in providing leverage from an initial investment can turn out to be a myth when account is taken of the alternative uses of resources…'(p. 31). In a later assessment, in the context of state support for major events, the Victorian Auditor-General observed that an input-output approach had been used in all recent (at 2007) evaluations of Victorian major events (Victorian Auditor-General 2007, p. 38). In that context, in a similar vein to the earlier report, the Auditor-General noted that in essence an input-output model takes a growth perspective; anticipating that new expenditure will always contribute to higher levels of production, employment and income (p. 38) but that:

> By effectively not accounting for crowding out effects and price changes, IO analysis can exaggerate the benefits of projects to an economy. (Victorian Auditor-General 2007, p. 132)

In a similar vein, the NSW Treasury has noted:

> Input-output [multiplier] analysis, however, will always indicate positive impacts - activity - without providing guidance as to whether such impacts correspond with net benefits. Poor investments, perhaps in heavily subsidised fields of endeavour, could be associated with greater levels of activity than good investments. (NSW Treasury 2007, p. 12)

Rama and Lawrence (2009) of the Victorian Department of Primary Industries in a research note 'Partial Multipliers: When More is Less' also concluded that as a result of conceptual and data limitations:

> …partial multipliers offer little practical guidance for public policy. Further, they do not eliminate the need for rigorous analysis of potential government investment on the basis of market failure and identification of a role for government, and robust assessment of direct benefits and costs. (p. 8)

These assessments demonstrate a long standing concern about the use of input-output multipliers to justify industry protection or government outlays or as a reflection of the economic importance of an activity.

The concerns focus on the fact that if labour, capital and other scarce resources are used for one purpose, they are not available for others.

3 How input-output tables can be put to work

While there are clear concerns about input-output multipliers and their misuse, the input-output tables on which multipliers are based provide a rich source of information about the structure of economies that is not available from other frameworks.

- Input-output tables provide key information for analysing linkages between activities.
- The tables also provide the underlying core database used in a range of economic models. While these models can overcome many of the limitations of input-output multipliers, they too, rely on restrictive assumptions which need to be tested before the models are applied. Used appropriately, these more sophisticated models can be used to meaningfully assess the impact of economic change, at the national and regional levels as well as at the global level. They can also be used to assess the distributional effects of change across the industries and regions included in the input-output table. If linked to household consumption and income data, the distributional effects of economic policy change on households can also be assessed.

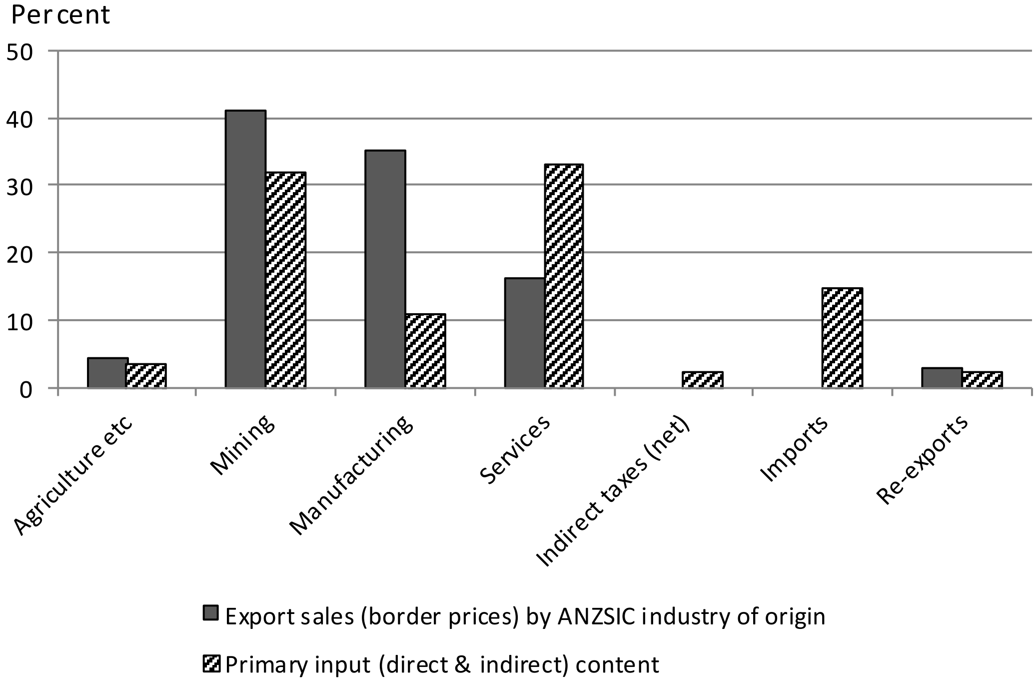
Analysing inter-sectoral, inter-regional and international linkages

Composition of Australia's exports

Foreign trade data at border values do not reveal the true importance of industries in Australia's export performance. In particular, they do not reflect the total contribution that services make to exports nor to the competitiveness and efficiency of the Australian economy. This is because services which are exported indirectly as embodied components of other goods and services are not recognised in basic data. When measured at border (free on board) prices, mining exports accounted for over 40 per cent of Australia's exports in 2008-09, while manufacturing exports (including processed agricultural and mining products) accounted for about 35 per cent (figure 1). Services industries on the other hand accounted for only 16 per cent of the border value of exports.

When account is taken of services industry value added embodied in *all* exports, the services sector contributed about one third of total exports in 2008-09. This is the largest contribution of any single sector and highlights the extent to which services are interrelated with other activities — both as an intermediate input to production and in the conveyance of products to the port. It also underscores the importance of services, such as trade, transport, finance and utility services, in determining the competitiveness of Australian goods on world markets.

Figure 1 **The composition of Australian exports by sector,[a,b,c] 2008-09**



a The value of export sales at border prices is inclusive of any transportation and other trade costs incurred in conveying ex-farm, mine or factory items to the port. **b** Under the Australian and New Zealand Industrial Classification (ANZSIC), exports of agricultural, mining, manufacturing and services are allocated to the industry of origin. For example, cereal grain and live animal exports are allocated to agriculture, coal and metal ores are allocated to mining, while processed agricultural products and metal products are allocated to manufacturing. **c** Indirect taxes (net) include taxes on production such as rates, land taxes and payroll taxes, and taxes on products such as the GST, excise taxes and import duties. Re-exports are goods imported into Australia and then exported without having been used or transformed in any way.

Source: Commission estimates based on ABS (A*ustralian National Accounts: Input-Output Tables 2008-09*, issued September 2012, Cat. no. 5209.0).

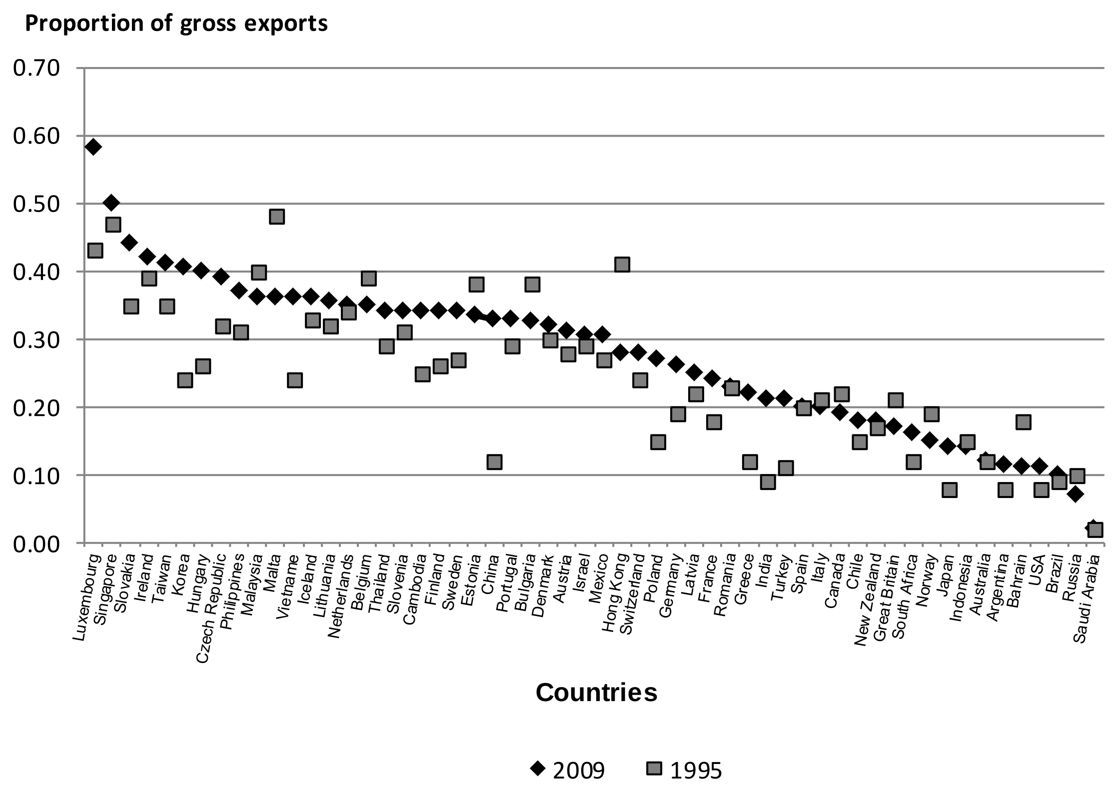
A policy environment that encourages efficient investment in services infrastructure and least cost provision of service supplies will improve Australia’s export performance. Similarly, with embodied imports accounting for around 15 per cent of inputs to Australia’s exports, policies that minimise the effective cost of imported supplies to producers will also improve export competitiveness.

International linkages and value added in trade

As the value adding contribution of industries to an economy’s exports can be traced using national input-output tables, so too can the value added contribution of countries to international trade be brought to light using international input-output tables.

Using the TiVA data base, the OECD reported with emerging global value chains and associated economic integration between economies, that there has been an increase in the foreign value added content of exports from the vast majority of reporting countries over the last two decades (figure 2). This is particularly so for the former transition economies of Eastern Europe and the economies of Asia.

Figure 2 **Foreign value added content of gross exports by economy has increased**[a]



a Economies ranked by 2005 proportions.

Source: OECD 2013, *OECD-WTO Database on Trade in Value Added*, Measuring Trade in Value Added, May 2013 Release, Paris.

In its analysis, the OECD noted that larger economies as well as those with significant mineral resources and those far from foreign markets and suppliers tend to have lower foreign content of their exports, than other economies. Of the 56 economies examined, Australia was ranked as having the seventh lowest foreign content — at 12 per cent. Economies with similar foreign content included the United States, Japan, Argentina and Indonesia.

Using a similar input-output approach, but based on the EC's World Input-Output Data Base, Kelly and La Cava (2013) report that, the United States and Europe are more important for Australia than is implied by conventional trade statistics. This comes about through global value adding chains as Australian content is exported to those locations indirectly via Asian manufacturing and assembly centres.

Kelly and La Caver also report that the value added content of Australia's exports is relatively high by international standards (figure 3)[2] — reflecting Australia's large endowment of natural resources and its geographic isolation, factors which limit its involvement in the growth of intermediate processing stages of global supply chains. In contrast, the domestic value added content of trade is typically lower and declining for countries close to production hubs that are involved in production sharing, such as those in Europe, Asia and North America.

Figure 3 **Value added contribution to exports for Australia is high by international standards,**[a]

a Value added to exports represents the amount of domestic content that is ultimately absorbed as final demand outside of a country (or country group). It is net of imports that are used in the production of goods ultimately exported for use in other countries (see figure 2). It excludes 'reflected exports', that is, exports exclude domestic content that is processed outside of a country and then imported (such as, imports of inputs to Australian industry containing Australia raw materials).

Source: Kelly and La Cava 2013.

The expanding scale of indirect links between economies highlights the importance of a trade-policy environment that avoids discriminatory arrangements and impediments to changing patterns of trade in goods and services between countries.

2 While the findings of the OECD-WTO report and the Kelly and La Cava paper broadly align, the point of reference for the indicators differs. The OECD-WTO data presented focuses on the foreign value added content of gross exports while Kelly and La Cava adopt the formulation of Johnson and Noguera (2012), a formulation also presented in the OECD-WTO TiVA database, to focus on the domestic value added content of foreign final demand.

Economic-environmental input-output tables

The concept of interdependence is not limited to financial flows as reported in standard input-output tables, but can be extended to encompass links between the production system and social and environmental systems. In the case of economic and environmental linkages, for example, economic and environmental flows and interactions between them can be portrayed using an economic-environmental input-output framework (box 4).

Box 4 **Economic-environmental input-output framework**

Quadrant 1 *Production and consumption of goods and services*	*Quadrant 2* *Waste and discharges to the environment from industry and households*
Quadrant 3 *Inputs of environmental resources to industry and consumption by households*	*Quadrant 4* *Environmental flows from natural systems and outflows being absorbed by those systems*

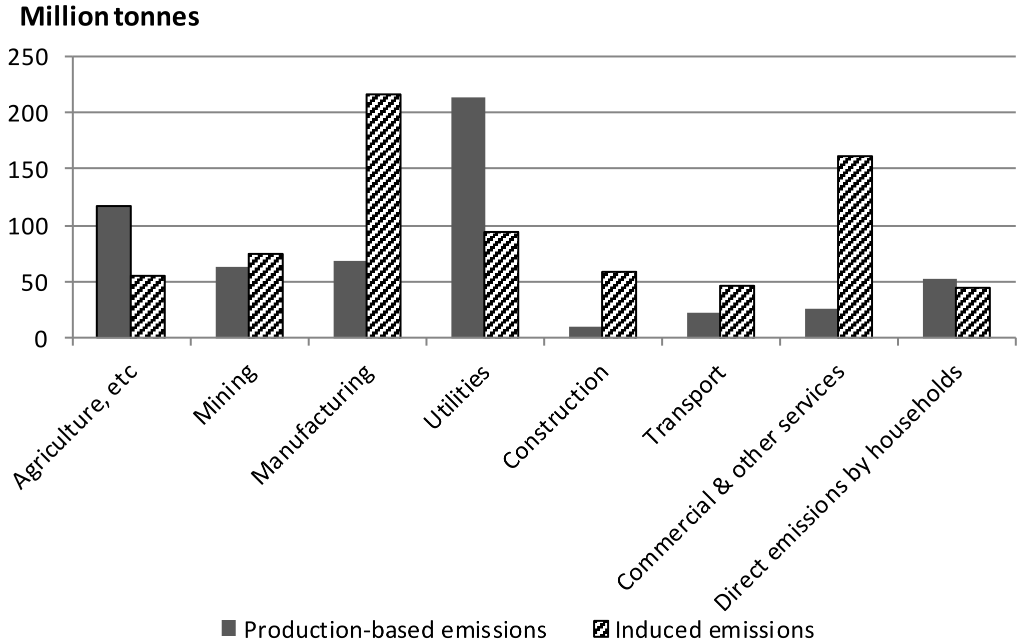
Note: Shaded areas would typically be measured in biophysical units. Non-shaded areas would typically be measured in monetary units.

Quadrants 1, 2 and 3, when taken together, represent the direct interactions between the environment and the production system while quadrant 4 is concerned with the natural function of environmental systems. Quadrant 4 is indirectly linked to the economic-environmental framework because the production system draws on resources created in natural systems and releases waste and other discharges into those systems.

In the case of carbon emissions, for example, physical emissions in Australia is estimated to have been 573 Mt in 2008-09 (DCCEE 2012).[3] When measured at the point of physical production, the utilities sector accounted for 213 Mt (over one third) of total emissions, while rural activities accounted for a further 117 Mt (about one fifth) (figure 4).

[3] Emissions represent physical emissions in Australia's physical territory. It is inclusive of emissions in respect of foreign visitors to Australia, but does not include bunkering of Australian vessels offshore.

Figure 4 **Sectors inducing and sectors producing carbon emissions differ,[a] 2008-09**



a Production-based emissions (the production approach) measure carbon emissions that are physically produced by industries and households within an economic territory. Induced emissions measure emissions embodied in final demand for domestically produced and imported goods and services and household activities (including those embodied in exports). Induced emissions *less* emissions embodied in exports represents the level of emissions pertaining to domestic consumption activities. A balance of trade in emissions would be equal to production-based *less* induced emissions.

Source : Based on ABS 2013b, Hao *et al.* 2012, DCCEE 2012.

Data on the point of physical emission, however, does not reveal the total emissions *induced* by final demand nor the nature of the final goods and services in which emissions are embodied. Using input-output methods, the ABS has estimated that 759 Mt of carbon emissions were induced by Australian economic activity in 2008-09. Of these, 531 Mt (or 70 per cent) were induced to satisfy domestic final demand with the remainder (228 Mt) induced by exporting.[4]

Whereas the energy and rural sectors are the main direct emitters, around half of induced emissions were embodied in downstream manufactured products (217 Mt) and commercial and other services (162 Mt) supplied to final users — such as retail and wholesale trade, meals and accommodation, and professional, public and personal services (figure 4). Changes in the energy intensity and the scale of

4 The estimated carbon induced by Australian economic activity is equal to physical production (573 Mt) *plus* emissions embedded in imports of goods and services (174 Mt) *plus* bunkering of Australian ships offshore (12 Mt).

downstream industries will have a substantial bearing on emissions induced by Australian productive and consumptive activities.

A more complete view

To overcome the basic limitations of multipliers as a tool for assessing the impacts of economic change, it is necessary to address the assumptions implicit in the use of input-output multipliers to recognise:

- resource constraints (the use of labour or capital by one activity or industry comes at the expense of its use elsewhere);
- the possibility of changes in the mix of inputs used in production due to changes in relative prices or technology; and
- the responsiveness of prices and other variables to policy changes affecting such things as tariffs on imported inputs, budgetary support to industry, industry productivity and workforce participation.

This can be done in a partial fashion through extending the basic input-output model, for example, by allowing prices to changes to equate demand and supply, introducing dynamics to account for changing input-output relationships, and allowing substitution between domestically produced and imported goods and services.[5] An alternative approach, also based on input-output data, is to construct a framework that explicitly recognises the interdependencies in the economy and that allows relative prices to play a key role. This approach to implementing the Walrasian general equilibrium concept has come to be known as computable general equilibrium (CGE) modelling with the first working model attributed to Johansen (see Johansen 1960 and Dixon, Koopman and Rimmer 2013).[6] This approach has been adopted by the Productivity Commission and its predecessors in reporting on the economy-wide and distributional effects of economic change.

5 The use of input-output tables in economic research has been the subject of volumes dating over a number of decades (for example, Chenery and Clark 1959, Brody and Carter 1971, Miller, Polenske and Rose 1989, Dietzenbacher, E. and Lahr, M. 2004), international statistical standard (UN 1973 and 1999), the Economic Systems Research — the journal of the International Input-Output Association, and international conferences on input-output tables and analysis the most recent of which was held in July 2013 (http://www.iioa.org/Conference/21st/).

6 CGE models are now widely used in economic impact analysis. A collection of papers by leading CGE model practitioners is provided in a recently published two-volume handbook (Dixon and Jorgenson 2013). The volume covers matters relating to single country and global models as well as technical aspects of CGE modelling.

The first CGE model implemented by the Commission was the ORANI model of the Australian economy developed under the auspices of the IMPACT project (Dixon *et al.* 1982).[7] The ORANI model was used extensively by the predecessors of the Productivity Commission in its assessments of the implications of tariff reductions and other policies affecting the Australian economy (for example, see Powell and Lawson 1986 and Dee 1994).

There are now a number of CGE models in the tradition of the ORANI model applied by the Commission. The main models applied by the Commission are the Monash Multi-Regional Forecasting (MMRF) model of the Australian economy, and the Global Trade Analysis Project (GTAP) model of the global economy (box 5). The MMRF model provides a detailed disaggregation of the Australian economy by state and industry and modelling of the economic behaviour of producers and consumers (CoPS 2008, PC 2012b).[8] The input-output tables also allow special purpose, as well as these larger CGE, models to be built. These can be useful, and have been used by the Commission, to examine the likely impacts of specific policy changes. The extent to which any model can estimate the distributional effects of a policy does, however, depend on the level of industry and regional detail included in the input-output table heart of these models.

A key feature of CGE models is that, in typical applications, they do not assume that there is an unlimited supply of labour and capital available at fixed prices.

- Aggregate employment is determined by the size of the working age population and assumptions about participation of people of working aged in paid employment, while real wages for workers vary in response to changes in competitiveness.
- Capital stocks vary (in the longer run) in order to equilibrate expected and actual rates of return, while capital income accrues to domestic and foreign investors in proportion to ownership shares.

That is, in the modelling, there are no ‘free lunches’.

CGE models provide considerable flexibility in managing assumptions about the structure of an economy, economic behaviour and resource constraints. And while considerable effort has gone into enhancing the functionality of the CGE models, in

7 The IMPACT Project was a quantitatively focused research effort conducted by the Industries Assistance Commission and other Commonwealth Government agencies in association with the University of Melbourne, The Australian National University and La Trobe University.

8 This model was developed as a multi-regional variant on the national MONASH model which itself was a derivative of the ORANI model (Dixon and Rimmer 2010).

their standard format, most still share some of the weaknesses of the open-static input-output model on which input-output multiplier analysis is based. For example, standard versions of MMRF do not include substitution possibilities between material and capital inputs to production, constant returns to scale are imposed on all industries, workforce participation and employment are usually assumed to be a fixed share of the working age population and workforce participants, respectively.

Awareness of the limitations of any model is essential in its application. Models should be chosen or developed to reflect the key aspects of the actual situation under analysis. Sensitivity to assumptions that underpin the model should always be tested and some measure of the uncertainty of point estimates of impacts provided in the policy analysis.

Looking ahead

The insights that CGE models can provide in policy analysis through the calibration of what are often offsetting effects makes them a valuable analytical tool. Increasingly powerful computers and flexible computer systems should see the continuing development of this type of economic model at the national and international levels.

The availability of timely and accurate input-output tables is critical for the effective application and development of CGE models and for the use of the tables in assessing the contribution of activities and industries to the economy. With a rapidly changing economy, regular updating of input-output tables is essential.

Input-output tables will also have much to contribute in the future to enrich policy debate through the integration of input-output data with social and environmental data. This information and the models that they will support will allow wider commentaries on the implications of changes in the economy, society and the environment.

Box 5 **Some recent applications of CGE modelling by the Productivity Commission**

MMRF modelling

The MMRF model has been used by the Commission to assess the impacts of Council of Australian Government (COAG) microeconomic reforms (PC 2005a,b, 2006 and 2012a,b) and the analysis of the implications of changes in assistance to passenger motor vehicle and textiles, clothing and footwear assistance (PC 2008a,b). Up to the 2012, study, the model was applied in 'comparative static' mode by the Commission. Under this approach, the impact of a policy change was measured against the representation of the economy in the model data base.

The 2005 study, conducted to support the Commission's review of National Competition Policy was novel to the extent that it linked the MMRF model to a unit record household income and expenditure data base to report the impact of economic reform on household income groups. The study also linked the model to a regional data base to disaggregate the impact of National Competition Policy reforms to over 50 sub-state regions (statistical divisions).

The 2012 study differed from the previous studies in that it applied the MMRF model in a dynamic mode. Under this approach, policy scenarios incorporating the impacts of a policy change are compared to a projected reference case (without the policy change). The dynamic approach provides a means of assessing the impacts of policy changes over time, taking into account possible changes in the structure of the economy and the interaction of such changes with policy impacts.

GTAP modelling

The GTAP model has been applied in the analysis of changes in barriers to trade and the cost of finance in the context of the global financial crisis, the European Union Common Agricultural Policy (CAP) and bilateral and regional trade agreements (PC 2009a,b, Costa *et al.* 2009, and PC 2010a,b).[9] In each application, the model was applied in comparative-static mode.

---

[9] In addition to the application of the GTAP model, per se, the Commission has also applied truncated versions of the model to highlight particular aspects of trade and finance between Australia and New Zealand (APC-NZPC 2012).

References

ABS (Australian Bureau of Statistics) 2001, *Census of Population and Housing : Time Series Profile*, Cat. no. 2003.0, ABS, Canberra.

—— 2009, *Information Paper: Introduction of revised international statistical standards in the Australian Tourism Satellite Account*, Cat. no. 5249.0.55.002, ABS, Canberra.

—— 2011, *Census of Population and Housing : Time Series Profile Second Release*, Cat. no, 2003.0, ABS, Canberra.

—— 2012, *Australian System of National Accounts, Concepts, Sources and Methods, Australia 2012, Edition 3*, Cat. no. 5216.0, ABS, Canberra.

—— 2013a, *Australian National Accounts, Input-Output Tables 2009-10,* Cat no. 5209.0, ABS, Canberra.

—— 2013b, *Towards the Australian Environmental-Economic Accounts, Information Paper,* Cat. no. 4655.0.55.002, ABS, Canberra.

—— (forthcoming), *Australian National Accounts, Input-Output Tables Commodity Details, 2009-10,* Cat no. 5215.0, ABS, Canberra.

Australian Productivity Commission and New Zealand Productivity Commission 2012, *Strengthening trans-Tasman economic relations*, Joint Study, Final Report.

Banks, G. 2002, *Interstate Bidding Wars: Calling a Truce*, Speech to the Committee for Economic Development of Australia, Brisbane.

Brody, A. and Carter, A. 1971, *Input-Output Techniques, Proceedings of the Fifth International Conference of Input-Output Techniques*, Geneva, North Holland, Amsterdam.

BCA (Business Council of Australia) 2012, *Pipeline or Pipe Dream? Securing Australia's Investment Future*, June.

Carr, K. 2012, *Car sector epitomises what we want to be*, The Australian, 14 January.

Carter, R. and Milanese, A. 1983, *The Economic Structure of the Latrobe Valley: Applications of a Survey Based Input-Output Table*, prepared for the Ministry of Employment and Training, October.

Centre of Policy Studies 2008, *MMRF: A Dynamic Multi-Regional Applied General Equilibrium Model of the Australian Economy*, Centre of Policy Studies, Monash University, Clayton.

Charles Sturt University 2010, *Growing Our Communities: Charles Sturt University's Regional Development Report 2010*.

Chenery, H. and Clark, P. 1959, *Interindustry Economics*, John Wiley & sons, New York.

Costa, C., Osborne, M., Zhang, X.G., Boulanger, P. and Jomini, P. 2009, *Modelling the Effects of the EU Common Agricultural Policy*, Staff Working Paper, Productivity Commission Melbourne.

DCCEE (Department of Climate Change and Energy Efficiency) 2012, *Australian National Greenhouse Accounts, National Inventory by Economic Sector 2009-10*, Canberra.

Dee, P. 1994, *General Equilibrium Models and Policy Advice in Australia*, Staff Information Paper, Industries Assistance Commission, Canberra.

Dennis, R. 2012, 'The use and abuse of economic modelling in Australia Users guide to tricks of the trade' The Australia Institute, Technical Brief No. 12, January.

Dietzenbacher, E. and Lahr, M. 2004, *Wassily Leontief and Input-Output Economics*, Cambridge University Press, Cambidge.

Dixon, P. and Jorgenson, D. 2013, *Handbook of Computable General Equilibrium Modeling*, Elsevier, Amsterdam.

——, Koopman, R. and Rimmer, M. 2013, 'The MONASH Style Computable General Equilibrium Modeling: A Framework for Practical Policy Analysis', in Dixon, P. and Jorgenson, D. *Handbook of Computable General Equilibrium Modeling*, Elsevier, Amsterdam.

——, Parmenter, B., Sutton, J. and Vincent, D. 1982, *ORANI: A Multisectoral Model of the Australian Economy*, Contributions to Economic Analysis 142, North Holland, Amsterdam.

Gretton, P. 2005, 'Australian Input-Output Tables', *The Australian Economic Review*, vol. 38, no. 3, pp. 319–32.

GTAP 2013, GTAP 8 Data Base 2013, https://www.gtap.agecon.purdue.edu/databases/v8/default.asp, (accessed 2 September 2013).

Hao, S., Legoff, G., Mahadeva, K., Chia, N. and Cadogan–Cowper, A. 2012 'Australian Greenhouse Gas Emissions: Experimental Consumption–Based Estimates Via Input–Output Analysis', 20th International Input–Output Association conference (IIOA) 2012, Bratislava, 24–29 June 2012.

IDE-JETRO 2013, Asian Input-Output Tables, http://www.ide.go.jp/English/Publish/Books/Sds/material.html (accessed 12 September 2013)

IAC (Industry Assistance Commission) 1989, *Using input-output analysis and multipliers*, Working Paper no. 12, Canberra.

Johansen, L. 1960 (Revised 1974), *A Multisectoral Study of Economic Growth*, Contributions to Economic Analysis 21, North Holland, Amsterdam.

Johnson .C. and Noguera, G. 2012, 'Fragmentation and Trade in Value Added over Four Decades', *NBER Working Paper no*. 2013-02.

Kelly, G. and La Cava, G. 2013, 'Value added trade and the Australian economy', *Reserve Bank Bulletin*, March Quarter, pp. 29-37.

Miller, R., Polenske, K. and Rose, A. 1989, *Frontiers of Input-Output Analysis*, OUP, New York.

MSD (Merck Sharp and Dohme Australia) 2002, *The Contribution of Merck Sharp and Dohme to the Australian Economy*, Technical report prepared for Merck Sharp & Dohme Australia Pty Ltd by Access Economics Canberra.

OECD 2012, *Input-Output Tables*, Latest update 25 March 2012 http://www.oecd.org/trade/input-outputtables.htm, (accessed 12 September 2013).

—— 2013, *Measuring Trade in Value Added*, OECD-WTO Database on Trade in Value Added, http://www.oecd.org/sti/ind/TIVA%20flyer%20FINAL.pdf (accessed 12 September 2013).

PC (Productivity Commission) 1999, *Impact of Competition Policy Reforms on Rural and Regional Australia*, Report no. 8, AusInfo, Canberra.

—— 2005, *Assistance to Tourism: Exploratory Estimates*, Productivity Commission Research Paper, Canberra.

—— 2005, *Review of National Competition Policy Reforms*, Report no. 33, Canberra.

—— 2005b, 'Modelling Impacts of Infrastructure Industry Change over the 1990s', Supplement to *Review of National Competition Policy Reforms*, Productivity Commission Inquiry Report No. 33, Canberra.

—— 2006, *Potential Benefits of the National Reform Agenda*, Report to the Council of Australian Governments, Canberra.

—— 2008a, *Modelling the Economy-wide Effects of Future Automotive Assistance*, Research Report, Melbourne.

—— 2008b, *Modelling the Economy-wide Effects of Future TCF Assistance*, Research Report, Melbourne.

—— 2009a, *Annual Report 2008-09*, Melbourne.

—— 2009b, *Modelling supporting the Productivity Commission Annual Report 2008-09*, Technical note, Melbourne.

—— 2010a, *Bilateral and Regional Trade Agreements*, Research Report, Canberra.

—— 2010b, 'A CGE Analysis of Some Economic Effects of Trade Agreements', Supplement to *Bilateral and Regional Trade Agreements*, Productivity Commission Research Report, Canberra.

—— 2011, *Disability Care and Support*, Report no. 54, Canberra.

—— 2012a, *Impacts of COAG Reforms: Business Regulation and VET*, Research Report, volumes 1-3, Canberra.

—— 2012b, 'Economy-wide modelling of impacts of COAG reforms', Supplement to *Impacts of COAG Reforms: Business Regulation and VET*, Canberra.

Powell, A. and Lawson, T. 1986, 'A decade of applied general equilibrium modelling for policy work', *IMPACT Working Paper* G-69, Melbourne.

Rama, I. and Lawrence, P. 2009, 'Partial, Multipliers: When More is Less', Research Note 2013, Victorian Department of Primary Industries, Melbourne.

RET (Department of Resources, Energy and Tourism) 2011, *Tourism's Contribution to the Australian Economy, 1997–98 to 2009–10*, September.

United Nations 1973, *Input-Output Tables and Analysis*, Studies in Methods, Series F No. 14, Rev 1, Department of Economic and Social Affairs, New York.

—— 1999, *Handbook of Input-Output Table Compilation and Analysis*, Handbook of National Accounting, Study in Methods, Series F No. 74, Department of Economic and Social Affairs, New York.

Victorian Auditor-General 2007, *State Investment in Major Events*, Victorian Government Printer, Melbourne.

Western Australia Department of Finance and Treasury 2002, 'The Use and Abuse of Input-Output Multipliers', Economic Research Paper, Government of Western Australia, Perth.

WIOD 2013, *The World Input-Output Data Base*, http://www.wiod.org/database/index.htm (accessed 12 September 2013).