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Employment support estimates - methodological framework

Office of Financial Management

Research & Information Paper

Preface

This Treasury Research and Information Paper describes the Input-Output (I-O) method used by the NSW Government for inferring estimates for jobs supported by Government Actions, Programs and Policies.

This publication is the support paper to the NSW Treasury Policy and Guidelines Paper *Guidelines for Estimating Employment Supported by the Actions, Programs and Policies for the NSW Government* (TPP09-7).

The framework presented in this research paper aims to assist project decision-makers in the public or private sector who are required to estimate jobs supported for Government initiatives. This is particularly relevant to nominated 'Go-To' people who assist in accelerating suitable projects.

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Note
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Contents:

Executive Summary

Governments provide direct employment opportunities in agencies and government owned businesses. In addition, Government programs, spending and actions have employment support impacts in the private sector. These employment support impacts can arise through several mechanisms. Some mechanisms have direct and visible impacts, while others are less direct and not observable and so have to be inferred.

This research paper describes the Input-Output (I-O) methodological framework used by the NSW Government for inferring estimates for the employment supported for some categories of Government policy. All such estimates are an exercise in approximation.

The NSW Treasury Policy and Guidelines Paper *Guidelines for Estimating Employment Supported by the Actions, Programs, and Policies of the NSW Government* (TPP09-7) is the companion document of this research paper. The guidelines paper details a comprehensive typology of possible Government actions, programs and policies[1] which is summarised in Appendix 1 of this paper. The guidelines paper also provides guidance on the derivation of employment support estimates, if appropriate, for each defined action category.

Employment supported estimates for aggregated actions and indirect employment that is not directly observable typically rely on the use of economic models. An economic model is a representation of the real world which attempts to capture the key economic relationships in a particular sector or for the economy as a whole.

Input-Output (I-O) models are commonly used to assess economic impacts. I-O models capture the transactions that link industry sectors across the economy in a simplified form. Although more limited than other models in the types of action that can be assessed, I-O models have the benefit of being simple, transparent and easy to use. For these reasons I-O model based multipliers are appropriate for estimating employment supported by some types of NSW Government actions.

The I-O model has several limitations and assumptions. Using an I-O model presumes a causal link between some government actions and employment support. All government spending is ultimately funded by a transfer of resources from taxpayers or by other sources, so jobs associated with this spending, while beneficial, may substitute for other activity that may have occurred had the resources been left in the hands of the taxpayer. Other than jobs from direct spending, flow-on jobs in other sectors indirectly supported by a government action cannot be readily observed.

In short, I-O based estimates of job impacts are only an exercise in approximation. They should not be interpreted as though they are literal (in terms of whether they are directly observable) or precise (in terms of certainty that the exact number of jobs estimated will eventuate). Point estimates should be thought of as sitting within a range of possible values.

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1 The term "actions" is used broadly throughout this paper to incorporate all government actions, programs, and policies.

The apparent simplicity of utilising I-O multipliers also makes these open to misinterpretation or possible unintended error. Therefore it is important to correctly interpret and present estimates from I-O models.

The following caveats should be borne in mind when interpreting I-O multipliers:

1. I-O multiplier based employment estimates should be presented as “jobs supported by” or “jobs associated with” government spending.

2. I-O multiplier based estimates applied to government spending relate to annual full-time equivalent jobs.

3. The I-O multipliers advised by NSW Treasury are based on Australia-wide data that excludes any flow-on to overseas jobs, so estimates of employment supported should not be presented as being “for NSW,” or as occurring only in a project’s region.

4. Point estimates should be thought of as lying within a range of possible values.

5. Estimates for employment supported should not be presented as though it were an additional benefit to the project’s gross output or impact on NSW’ net output (gross state product).

Introduction

There are two main methods for deriving employment support estimates:

- project specific estimates – bottom up
- economic model based estimates – top down[2].

Direct employment such as that associated with infrastructure projects is visible, and in principle could be verified. Before the fact it may be based on some type of project planning model. All estimates for aggregated actions and for indirect employment that is not observable have to be based on an economic model.

An economic model comprises a theoretical construct that captures the salient economic production mechanisms. Mathematical equations can be used that incorporate numerical estimates for the key model parameters and databases. The empirical values in a model may be derived from various sources including published data (e.g. ABS statistics), other published analysis, survey data, econometric analysis, and/or be based on prior reasoning. A model could be limited to a particular sector of the economy or could be an economy wide model.

Commonly used economic models for assessing economic impacts include computable general equilibrium (CGE) models and input-output (I-O) models.

CGE models can be used to assess the impacts of a broad range of actions. CGE models utilise input-output data, but also incorporate a detailed representation of the consumption and income sides of the economy, capturing the multiplicity of flow on interactions between different production sectors – hence the descriptive term general equilibrium. A CGE model can provide a very detailed assessment of the economy wide flow on economic impacts that originate in a particular industry sector.

CGE models are very complex and as a result their use requires high-level expertise. Estimates from a CGE model may be sensitive to assumptions imposed on the model. CGE modelling cannot avoid subjective judgements and relies on data that has limitations, including sampling errors.

In particular, while a CGE model can provide detailed projections of changes in occupational demand and industry sectoral employment, aggregate employment estimates depend on assumptions about wage flexibility and occupational mobility. Estimates of aggregate employment impacts from a CGE model are a reflection of assumptions in the model rather than being of independent predictive value. Furthermore as most individual Government actions are small relative to the State economy, few will have more than a negligible impact economy wide. CGE models are therefore usually only used to assess the impacts of major economic reforms and very large projects and events.

Input-output models are more limited than CGE models in the types of action that can be assessed, utilising a much simpler representation of the economy. An I-O model can provide a range of industry sector "multipliers" that capture possible backward and forward linkages associated with an initial "impact" such as that associated with the Government's infrastructure program. An I-O model has the benefit of being simple, transparent and relatively easy to apply.
I-O models have been widely used internationally for the analysis of regional economic impacts in particular.

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[2] Project specific measures could utilise other types of modelling (e.g., linear programming, queuing), so the distinction between the two methods is not absolute.

The application of I-O models is long established and a standard technique. Given these considerations and in the absence of further detailed information on a particular government program or project, I-O model based multipliers provide an appropriate basis for estimating the employment supported by the NSW Government actions that impact on the demand side of the economy.

Model based economic impact assessment is not a substitute for a thorough economic analysis of a policy. The appropriate method for analysing policy alternatives is benefit cost analysis (BCA)[3]. BCA considers the best use of resources and as such treats labour inputs as a cost. An I-O based economic impact analysis is best seen as a complement to a BCA and does not provide evaluative guidance. An I-O model will estimate flow on impacts irrespective of the qualities of the policy triggering those impacts.

Input-Output Modelling

Input-Output models are based on an Input-Output table for a region or a nation. An I-O table represents the regional or national economy as a number of discrete industry sectors. In order to produce its output each industry sector purchases *intermediate inputs* from other domestic (or regional) industries and combines these with imported inputs along with the primary factors of production - labour, capital and land. Many industries must consume some of their own industry's output to produce additional output for sale. For example, a power station must consume power – it will generate more electricity than it sells to cover its own needs. An I-O table arranges these transactions as a matrix.

As such, an I-O table captures the transactions that link industry sectors across the economy in a simplified form. An I-O table comprises estimates of these transactions for a given financial year within the *National Accounts* statistical framework utilised by the Australian Bureau of Statistics. This means that the value of transactions recorded in an I-O table can be reconciled to the national account aggregate measures such as Gross Domestic Product (GDP).

A variety of "multipliers" can be derived from an I-O table, including output multipliers, value added multipliers, employment multipliers and income multipliers. Only employment multipliers are required for deriving estimates for employment supported[4].

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3 See NSW Treasury, *NSW Government Guidelines for Economic Appraisal* (TPP07-5).

4 Appendix 3 provides an example of a simplified I-O table, and the derivation of employment multipliers from that table.

I-O multipliers capture the relationship between net and gross economic activity (e.g. turnover and final demand), contingent on assumptions regarding industry production functions[5]. Multipliers can be derived for each industry sector in an I-O table.

For each industry sector there are four different types of employment multiplier. Each type of employment multiplier covers each of the four separate components of employment supported to be estimated, which is associated with the final demand for the particular industry sector. These components capture the *backward linkages* associated with the supply of intermediate inputs to the industry sector, and the *forward linkages* associated with the consumption spending that is supported by the associated wages earned. These four employment multipliers are:

- The *initial effect* multiplier captures the direct employment within the industry sector.
- Employment supported within the industries that directly supply intermediate inputs to the final demand industry sector is given by the *first round effect* multiplier.
- Further flow on employment supported within the suppliers of the suppliers and their suppliers, etc., is given by the *industrial support effect* multiplier.
- Employment supported from the spending of associated earnings is given by the *consumption effect* multiplier.

In the national accounts framework all government spending is a component of final consumption or investment demand (i.e. a direct component of gross domestic product or GDP). Infrastructure spending is treated as final investment. Therefore, I-O employment multipliers can be applied to NSW Government spending.

The first step in formulating an employment estimate requires allocating the associated spending to be undertaken to the relevant I-O table industry sectors. These are the sectors receiving the direct impacts. For many infrastructure projects, a large component of direct spending will be within the construction sector.

Appendix 2 sets out the approach used to derive employment multipliers for the aggregate NSW Government infrastructure program, as weighted averages of the relevant sectoral multipliers. The weightings reflect the composition of the infrastructure program in the 2009-10 Budget, as published in Budget Paper No. 4. Over 80 per cent of the direct spending will be in construction related sectors, with the remainder being for land and buildings and the purchase of various types of equipment.

Each sector's *initial effect* employment multiplier reflects the average number of full time equivalent employees in the industry sector for each million dollars worth of the sector's annual output. The budgeted annual spending for a sector multiplied by the initial effect multiplier therefore gives an estimate for the full-time equivalent (FTE) annual employment directly supported by the spending. This assumes the composition of the budgeted spending is similar to the sector's average. For the construction sectors, a direct employment estimate will include both on-site and off-site employment for all activities classified within the construction sectors.

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[5] I-O multipliers are not conceptually akin to Keynesian macro multipliers.

The *first round* I-O employment multiplier estimates the average employment required to produce the intermediate inputs supplied directly to the primary industry sector. For a construction project this would include materials such as steel and concrete. To estimate first round FTE annual employment supported, a primary sector's annual direct spending is simply multiplied by the first round multiplier.

The initial and first round effects are fairly direct. As an alternative or to check I-O based estimates, it may be possible to estimate such direct employment impacts via a detailed analysis of actual or planned expenditure for some projects.

The *industrial support effect* I-O employment multiplier relates to the flow of intermediate input purchases throughout the economy. Those sectors supplying materials to the primary sector will require their own inputs.

For a construction project the mining and transport sectors will supply the steel and concrete used in the construction. These demands on the mining and transport sectors will in turn have further backward linkages. The combined *first round* and *industrial support effects* are termed the *production induced effects*. The sum of the *production induced* and *initial effects* multipliers give the *simple multiplier*.

Finally, the earnings associated with the employment supported by the *initial* and *production induced* effects provides a channel of impacts via household spending. For example, construction workers employed on the job site will spend their wages from the project on various household goods and services leading to possible employment impacts in those industries supplying those goods and services. This is the *consumption induced effect* which added to the simple multiplier gives the *total multiplier*. As *consumption induced effects* are tentative and unobservable it is good practice to exclude them from I-O impact analysis and use the simple multiplier.

Interpreting Employment Estimates from an I-O Model

It is essential that estimates relating to government policy actions that are derived from I-O models are properly interpreted and appropriately presented. Taking into account the various assumptions of I-O modelling, the most important considerations are outlined briefly below. The next section provides further elaboration of some of these issues.

1. Estimates of jobs supported based on I-O employment multipliers should not be interpreted or represented as additional jobs created. Rather, I-O multiplier based employment estimates should be described as “jobs supported by” or “jobs associated with” government spending.

   The I-O model provides a reasonable and transparent method for approximating the direct and flow on employment supported by sectoral demand, such as the demand associated with government infrastructure spending. Some of these jobs, however, may already exist and may substitute for existing jobs in other sectors. (For example, a construction worker employed on a government project may shift from one completed project, to a project that is part of the public infrastructure program elsewhere). Moreover, any indirect flow-on job impacts are not observable.

2. I-O multiplier based estimates applied to government spending relate to annual full-time equivalent jobs. I-O multiplier based employment estimates derived from turnover (sales) relate to full time equivalent jobs supported only for as long as the project continues to operate at a given scale.

3. The ABS publishes I-O tables for Australia, but not for NSW or any other States. Estimates using multipliers from national I-O tables capture impacts that can happen anywhere in Australia and not in a specific state or a specific project’s influence area. Therefore multiplier based estimates for employment supported should not be reported as being “for NSW” or as occurring only in a project’s region.

4. Estimates for employment supported should not be presented as if it is an additional benefit to the project’s gross output or impact on NSW’ net output (Gross State Product). This would amount to double counting.

I-O Model Assumptions and Limitations

Government funding impacts

Any government spending taken in isolation is a source of demand that helps support some employment. All government spending, however, has to be funded, either through a transfer of resources from current or future taxpayers or by some other funding mechanism. This implies that economic activity associated with government programs may ultimately to some extent substitute for activity that would have occurred had the resources been left in the hands of the taxpayer[6].

However, there are clear benefits from mitigating any downturn and avoiding adjustment costs, such as those associated with periods of unemployment. There is scope for government to:

- use debt to boost demand and moderate the downturn during periods of economic weakness
- attract additional demand from outside the jurisdiction (e.g., demand for exports or foreign investment)
- pursue actions that improve the supply side of the economy, enhancing productivity and supporting a greater rate of economic growth than otherwise.

Resource displacement

Net employment cannot increase unless a project draws in labour that would otherwise be unemployed. If a project makes demands on areas of skill shortages this could put upward pressure on wage rates. (The same logic applies for the other resources required for a project.) Therefore, estimating the impact of a project on unemployment requires supplementary analysis to the application of employment multipliers.

Imports

An input output table includes every industry sector's imported inputs. For the Australian I-O table this relates to imports from overseas. For the component of spending that flows into import demand the associated employment supported will be overseas. If the focus is on domestic impacts, the multipliers applied should exclude imports[7] and will be smaller than multipliers that include them. In practice it is straightforward to calculate such multipliers, and the multipliers that NSW Treasury supplies will be on this basis.

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6 The question of the extent to which governments can stimulate economic activity is complex and subject to debate, and is well beyond the scope of this paper.

7 In technical terms, this requires deriving the multipliers from an I-O table based on a "direct allocation of competing imports".

Averaging and homogeneity of industry sectors

The I-O table divides the economy into a number of industry sectors. In using the table as model of the economy, each industry is assumed to produce a single homogeneous product, using a constant proportions linear production function, i.e. a doubling of output would imply a doubling of all inputs. Any $1 million worth of output from the construction sector or the mining sector is therefore assumed to be identical to every other $1 million of output from those sectors.

The data in an I-O table measures the annual average relationship between output and inputs for each sector for the relevant year. Even if an industry's output was homogeneous, marginal impacts from small changes in the output of an industry will generally differ from average impacts. Applying multipliers assumes that average and marginal impacts are similar.

There is inevitably some judgment required to group activities into a homogeneous "industry sector". The ABS' standard industry sector classification is modified from time to time to accommodate new and changing industries. Of particular note for government investment spending, the ABS' I-O industry classification for 2004-05 does not contain a single "Information Technology (IT) industry." Some IT related activity is a cost component of the various industry sectors classified.

Employment multipliers combine I-O industry sector output multipliers with employment ratios for each sector, in terms of full time equivalent employment per $m of annual output.

Converting employment supported estimates to annual full time equivalence can assist comparability and aggregation. This is of particular importance for aggregate estimates for infrastructure investment because many different parties could be involved in deriving estimates. When a jobs estimate for a project is received from a contractor or proponent the conversion to full time equivalent positions maintains clarity of communication.

In the absence of specific information for an industry sector, part time employees for a given period should be assumed to be 0.5 of a FTE job, and casual employees 0.33 of a FTE job.

For example, a project that employs 10 people for two years in full time positions, and 10 people for two years in part time positions and three casual employees for one year, could be converted to annual full time equivalent jobs as follows:

Full time employees	10 x 2 = 20
Part time employees	10 x 2x 0.5 =10
Casual employees	3 x 0.33 = 1
Total annual FTE	31

Industry structure change and technology change

Over time the industry structure of the economy changes and evolves and an I-O table for a given year will become outdated. Such structural change tends to be a fairly slow process. (There are exceptions, and some shocks to the economy can induce rapid change. New technology will cause structural change over time and change industry production relationships.)

As it is unrealistic and unnecessary to have new I-O tables each year, in the past the ABS has normally published new I-O tables for Australia every two or three years. Preparing I-O tables is a large and complex task, and it typically takes three or more years from the year of a table to its publication.

Multipliers from different periods may not be directly comparable because of changes in sectoral definitions and for other technical reasons.

Timing of impacts

I-O models can provide estimates of employment supported assuming that all of the flow on impacts have been completed but does not have a defined time dimension. An I-O model is based on a snapshot of the economy for a particular 12 month period. The application of multipliers provides no information about the timing of impacts. In fact, in some instances it could take many months or years for direct spending to complete its flow on impacts throughout the economy. If spending is ongoing, however, it is reasonable to treat supported employment as being contemporaneous and ongoing. This is the case for many government programs.

I-O table data issues and limitations

The ABS does not derive I-O tables for individual States and Territories and so the ABS' I-O tables for the Australian economy are the best data available, notwithstanding that the data has significant limitations. I-O tables for NSW have been constructed by other parties, but as available state level data is inferior to that for the nation, state I-O tables tend to have bigger sampling errors and much more aggregated industry structures than the ABS' national tables. (The 2004-05 I-O tables used to calculate employment multipliers in this paper categorise the economy into 109 industry sectors.[8])

I-O multipliers are derived from I-O tables using matrix algebra. The ABS has not published the I-O multipliers for recent I-O table releases. This may be because software packages that can derive multipliers from an I-O table are now readily available and users can easily derive for themselves whatever particular multipliers are of interest. The downside of this is that it may not always be clear whether estimates from different sources are using the same multipliers, and whether they are directly comparable.

The industry sector estimates compiled by the ABS for an I-O table rely on data which the ABS describes as being "of varying quality". The ABS publication *Australian National Accounts: Concepts, Methods and Sources* (catalogue 5216.0) contains a detailed discussion of the "quality" of the statistics. All sample data is subject to sampling errors and some table entries may be "synthetic" model based estimates. The ABS states "note that in the compilation of input-output tables various modelling techniques are used to populate the tables". Adjustments have to be made to initial "raw" estimates to get an input-output table to balance - the total sum of outputs for the economy must equal the sum of inputs. I-O table compilers use standard algorithms to spread

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8 ABS Catalogue 5209.0.55.001 - *Australian National Accounts: Input-Output Tables - Electronic Publication, 2004-05 Final*, published 19 November 2008.

uniform adjustments across a table to get it to balance, which introduces another source of error.

Associated Document

The NSW Treasury policy and guidelines Paper *Guidelines for Estimating Employment Supported by The Actions, Programs, and Policies of the NSW Government* (TPP09-7) sets out the policy for the derivation of employment support estimates from all types of NSW Government actions, programs and policies; provides guidance for deriving employment support estimates related to infrastructure investment; and guidance for deriving employment support estimates for Go-To people.

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Appendix 1

Typology of Government Actions, Programs and Policies

Category 1 – Government Final Demand spending

1.1 NSW Government Investment - Infrastructure (or Capital) Program
1.2 NSW Government consumption expenditure

Category 2 – Industry Assistance

2.1 Discretionary industry assistance
2.2 Major Events
2.3 Major Private Sector Projects
2.4 Generic investment attraction
2.5 Industry promotion
2.6 Industry development
2.7 Business support and advice
2.8 Grants, rebates and subsidies

Category 3 – Supply Side Measures

3.1 Red tape reduction
3.2 Training
3.3 Taxes, fees and charges
3.4 Infrastructure
3.5 Goods and Services procurement
3.6 RD&D support
3.7 Other micro-economic policies

Source: *Guidelines for Estimating Employment Supported by the Actions, Programs and Policies of the NSW Government* (TPP09-7), section 1.

Appendix 2

Calculation of Employment Multipliers for 2009-10 Infrastructure Program

This appendix describes the procedure used to calculate the weighted average employment multiplier for the NSW Infrastructure Program for 2009-10. Over 2,200 projects in NSW 2009-10 Budget Paper No.4 were classified to a number of categories corresponding to relevant industry sectors in the ABS 2004-05 Input-Output tables. The mapping of the categories and examples of BP4 projects are shown in Table A2 below.

Table A1: Employment Multipliers, FTE per $m (derived from ABS 2004-05 Input-Output Tables)

ABS Industry Sector	Initial impact (1)	Production-induced effect (2)	Simple employment multiplier = (1) + (2)	Consumption induced effect
Scientific research, technical & computer services	5.9	16.3	22.3	7.0
Motor vehicles & parts, other transport equipment	4.4	4.7	9.1	7.6
Other electrical equipment	3.8	2.1	5.9	1.0
Photographic and scientific equipment	4.4	0.5	4.9	0.6
Other machinery and equipment	4.4	1.6	6.0	0.7
Other property services	1.9	27.8	29.7	19.3
Construction trade services	7.2	11.8	18.9	5.4
Residential building	2.2	1.8	4.0	1.0
Other construction	2.1	3.0	5.0	1.5

The weighted multipliers for each of the categories/sectors in Table A1 were summed to determine a single “simple employment multiplier” for the total infrastructure program. This simple employment multiplier has a rounded value of 10 - meaning that every $1 million of infrastructure spending can support around 10 full-time equivalent jobs per annum. This comprises an initial impact of around four FTE jobs, and a flow on production-induced effect of around six FTE jobs. These multipliers apply in particular to the 2009-10 infrastructure program and should not be used for other purposes. Given the various approximations in the ABS data, and to avoid false precision, it is appropriate for the estimated multiplier to have been rounded to the nearest whole number. Where the estimate refers to the aggregate infrastructure program, it may be reasonable to round this to the nearest 10,000.

The “simple multiplier” excludes the consumption induced effect. If the consumption induced effect was also included, the multiplier for the 2009-10 infrastructure program would be around 13. This value is known as the “total multiplier”. However, as noted above, the consumption induced effect is very indirect. Therefore to be conservative, job support estimates should be based on the simple multiplier. The category/sectoral weights that have been used to derive the aggregate multiplier are specific to the infrastructure program in the 2009-10 Budget. The weights would be expected to change over time as the composition of the program changes. The sectoral multipliers could also change if calculated from a different set of input-output tables.

Table A2: Major Expenditure Sectors for NSW Government Public Infrastructure Program

Types of projects in BP4	Examples of types of public capital expenditure that may be included in this category	ABS input-output sectors (codes) for BP4 project mapping
Information communications and technology (ICT) projects	Information and communications technology (ICT), systems and services – e.g., this may include the cost of acquisition of hardware and software as well as implementation and related services.	Scientific, research, technical and computer services (7801)
Transport equipment	Transport equipment – e.g., this may include buses and motor vehicles, including fleet replacement and navigational aids.	Motor vehicles and parts, other transport equipment (2801)
Electrical equipment	Electrical/electronic equipment – e.g., this may include photocopiers, cash registers, electronic communications devices, transformers.	Other electrical equipment (2808)
Photographic and scientific equipment	Photographic and scientific equipment – e.g., this may include aerial or digital photographic equipment, highly specialised medical or diagnostic equipment.	Photographic and scientific equipment (2805)
Other equipment and plant	This is a residual category for equipment, to which are classified those projects which do not clearly belong in the other equipment categories.	Other machinery and equipment (2810)
Land and buildings	This may include the cost of improvements to building or grounds, site acquisition, capital costs of office accommodation such as office refurbishment.	Other property services (7702)
Construction-related services	This may include planning, studies, pre-feasibility activities, obtaining development approvals, or the cost of consultancies to undertake such activities; may also include work that largely entails one-off tasks by tradespersons.	Construction trade services (4201)
Residential Construction	This may include expenditure on public housing, capital costs of dwelling units for social welfare purposes (e.g., dwellings administered or acquired by DADHC), housing for teachers.	Residential building (4101)
Other Construction	This is a residual category, to which are classified those projects which are not equipment but which do not clearly belong in the other construction categories.	Other construction (4102)

Appendix 3

Input-Output Analysis and the Derivation of I-O Multipliers

The I-O Transactions Table

The starting point for input-output analysis is the I-O *transactions table.* This table is based on the assumption that anything produced or sold by a given industry is either consumed by households or governments of private businesses; or used as an input to the production of another industry. Input-output transactions tables show the values of flows in the economy for a particular period. At a given level of industry aggregation the tables show all of the inputs required to produce all of the industry outputs for the period.

Each industry sector is assumed to produce a single “homogeneous” output. In order to produce its output an industry requires inputs from other industries known as *intermediate inputs* and inputs of primary factors of production, labour, capital and land. Many industries even consume some of their own output in the production of additional output. For example, in order to produce an additional unit of electricity for final use, a power station will need to generate more than one unit because of its own internal consumption.

Table A3 illustrates a simple I-O transactions table for an economy with only two industries (M and N), a household sector (H) and government sector (G) and primary factor inputs labour (L) and capital (C). In this simple example, there are no imported inputs. In practice the treatment of imports is important because imports are leakages from the domestic economy and will reduce the flow on effects captured in the I-O multipliers.

All the column entries for a particular industry are the inputs to that industry. The sum of the column entries therefore gives the turnover for that industry. Profit (or gross operating surplus) is included as the cost of using capital.

Table A3. A Simple Input-Output Transactions Table, $.

		Intermediate Demand		Final Demand		
		M	**N**	**H**	**G**	**Total output**
Inputs	**M**	200	500	300	0	1,000
	N	400	100	200	250	950
	L	200	300			
	C	200	50			
	Total Inputs	1,000	950			

In Table A3, reading across the first row, of the $1000 worth of output produced by industry M, it sells $200 worth to itself, $500 worth to industry N and $300 worth to households (household sales being final consumption).

Reading down the second column, in order to produce $950 worth of output, industry N buys $500 worth of input from industry M, $100 worth from itself, hires $300 of labour and consumes $50 of capital (i.e. profit).

Generally in an I-O transactions table, the row entries for a particular industry are outputs from that industry. Some of the outputs are utilised as inputs to other industries and some are output to *final demand*. Final demand may be in the form of consumption or investment by either the household or the government sectors as well as for export. The sum of final demand from all sectors represents the net output of the economy, often measured by GDP. While the total turnover of the economy in Table A3 is worth $1,950, GDP is only $750.

GDP can be calculated from both the income side and from final demand. From the income side, labour earns $500 and capital earns $250, giving a total of $750. Final demand for M is $300, and for N is $450, giving a total GDP of $750.

One of the important features of the transactions table is that it balances, in that the sum of the inputs must be equal to the sum of outputs.

Given that the transactions table describes the economy in terms of industry flows it can be manipulated in order to explore particular aspects of the economy. This process is at the core of input-output analysis. Such analysis treats the input-output table as providing a description of a fixed proportions (linear) production technology for each industry sector.

Derivation of Technical Coefficients

The transactions table can be used to derive a matrix of so called *technical coefficients*, which represent the ratio of the input of a given industry to the total output of the industry to which it is an input. From table A3, of the 1000 units produced by industry M, 400 are provided as inputs from N. Therefore the technical coefficient a_{NM}=400/1000 = 0.4. The matrix of technical coefficients is given in table A5.

Table A4. Matrix of Technical Coefficients (the 'A' Matrix) – First Round Effects.

	M	N
M	0.2	0.53
N	0.4	0.11

We can use these coefficients to express the annual production of industry M, as given in the first row of table A3, as follows:

1000 = 0.2x1000 + 0.53x950 + 300 (1)

Derivation of Multipliers

The technical coefficients provide the basis for deriving I-O multipliers.

Where X is a vector of all industries and Y a vector of final consumption, then a generalised version of equation (1) in matrix notation is:

$$X=AxX + Y \qquad (2)$$

where A is the matrix of technical coefficients. Equation (2) can be re-arranged to express industry outputs as a function of final consumption demand:

$$X=(I-A)^{-1}xY \qquad (3)$$

where I is the identity matrix. The matrix $(I-A)^{-1}$ in equation (3) is a matrix of multipliers, i.e. the relationship between industry outputs and final demand.

The values of the $(I\text{-}A)^{-1}$ matrix based on the values for A given in table A4 are as follows:

Table A5. $(I\text{-}A)^{-1}$ Matrix – Simple Output Multipliers.

	M	**N**
M	1.77	1.04
N	0.79	1.58

We can consider the impact of each $10 of final demand (net output) for industry M, i.e. the *output multipliers*. The impact can be broken down into several categories – the *initial impact*, the *first round effect*, the *industrial support effect* and the *consumption effect*.

A $10 increase in final demand is known as the *initial effect*. The technical coefficients matrix in table A4 measure the *first round effect*, the immediate increase in outputs required to produce the additional $10 worth of final output. As table A5 shows, a $10 increase in output from M will require an additional $2 worth of input from M and $4 input from N. The total first round effect will be $6.

The values in the first column of table A5 give the total *simple multipliers* for industry M. These quantify all of the backwards linkages as a consequence of the first round effects. An increase of $10 of final demand for M will require a total additional output of $17.70 from M and $7.90 from N. In order for households to be able to consume $10 worth of M, the economy must produce $17.70 of M and $7.90 of N.

The difference between the *simple multiplier* and the *initial effect* plus *first round effects*, are known as the *industrial support effects*. In this example, the *industrial support effects* on industry M of a $10 increase in final demand for M is equal to $5.70 ($17.70 - $10 - $2) and the industrial support effects on industry N of a $10 increase in final demand for M is equal to $3.90 ($7.90 - $4). Total *industrial support effects* for M are therefore equal to $9.60.

Table A6. Output I-O Multipliers (per $10).

Per $10	Initial effect	First round effects	Industrial support effects	Simple multipliers
M	10.0	6.0	9.6	25.6
N	10.0	6.4	9.8	26.2

Table A6 shows the standard set of output multipliers from the backward linkages. In a similar way to the derivation of the output multipliers, other multipliers including income and employment multipliers can be derived.

Employment I-O Multipliers

The derivation of employment input-output multipliers requires changing the units of analysis from $s of output to employees per $ of output. If the wage rate in our simple economy is $1 per employee, then the $1000 of output produced by industry M utilises 200 employees, and the $950 of output from N utilises 300 employees. The ratio of employees per $1 of output in industry M is 0.2, and in industry N is 0.32.

A $10 increase in final demand for M will directly require 2 additional employees in industry M. This is the *initial effect* for employment in M of a $10 increase.

The *first round effects* are given by the technical coefficients in table A4 and will have employment effects in both industries. A $10 increase in final demand for M will induce a further $2 worth of inputs from M, and $4 worth from N.
The further $2 in M requires a further 2 x 0.2 = 0.4 employees, and the $4 induced in N requires 4 x 0.32 = 1.28 employees. This gives a total first round impact for M of about 1.7 employees per $10.

The *simple multiplier* implies that a $10 increase in final demand for M is associated with $17.70 worth of M. $17.70 worth of M requires 17.7 x 0.2 = 3.54 employees, while the $7.90 worth of N requires 7.9 x 0.32 = 2.49 employees. Therefore once all of the backward linkages have been taken into account the total employment supported by a $10 increase in final demand for M is about 6.0 employees.

The *industrial support effects* are determined by subtracting the initial and first round effects from the simply multiplier. The sum of the first round and industrial support effects are known as the *production induced effects*.

Table A7 shows all of the employment multipliers for both industries. In this example, the production induced effects are bigger than the initial impact in both industries.

Table A7. Employment I-O Multipliers (per $10).

Per $10	Initial effect	First round effects	Industrial support effects	Simple multipliers
M	2.0	1.7	2.3	6.0
N	3.2	1.4	2.5	7.1

Forward Linkages

Forward linkages arise because the output of the different industry sectors provides household incomes, which themselves will have forward linkages known as *consumption effects*. Such expenditure will have further flow on effects for industry outputs, income and employment. The relevant multipliers are derived from an I-O table that includes household income and spending.

It is reasonable practice to exclude forward linkage impacts from I-O model based economic impact analysis. These linkages are predicated on common consumption patterns, while in practice consumption patterns can vary significantly according to economic conditions.

Appendix 4

Formulas for the calculation of the Simple Multiplier and its components

MULTIPLIER	VARIABLE NAME (in ABS Info Paper cited below):	DEFINITION/FORMULA
Initial effect	**E**	"E" is a [109 X 1] vector of employment coefficients. This vector is calculated as = (total FTE* by industry)/(total production by industry), ***where:*** the [109 X 1] array (total FTE* by industry) is taken from Table 20 of the 2004-05 I-O Tables#, and the [1 X 109] array (total production by industry) is the transposition of the row labelled 'Australian production' in Table 5 of the 2004-05 I-O tables#.
First round effect	**V1**	V1 = "E" x "A" ***where:*** Matrix “E” is as defined above, and Matrix "A" is defined as the [109 X 109] intermediate usage block of Table 6 of the 2004-05 I-O tables#. Table 6 is called the “Direct Requirements Coefficients Matrix based on direct allocation of imports”.
Simple Employment Multiplier	**V2**	V2 = "E" x [Inverse A] ***where:*** Matrix “E” is as defined above, and Inverse "A" is defined as: the [109 X 109] matrix in Table 7 of the 2004-05 I-O tables#. Table 7 is called the “Total Requirements Coefficients Matrix based on direct allocation of imports”. Table 7 is the Leontief inverse of Matrix "A" defined above.
Industrial support effect		Calculated as the Simple Multiplier less the First Round Effect less the Initial Effect.
Production - induced effect		Calculated as the sum of the First Round Effect plus the Industrial Support Effect.

- I-O Tables = refers to Input Output tables published in ABS Catalogue 5209.0.55.001 – *Australian National Accounts: Input-Output Tables - Electronic Publication, 2004-05 Final* obtained from the following web page: http://www.abs.gov.au/ausstats/abs@.nsf/mf/5209.0.55.001

* - FTE = full time equivalent employment.

Source of procedure for calculating multipliers: ABS Cat 5246.0, Australian National Accounts, *Information Paper: Introduction to Input-Output Multipliers* (1989-90), Appendix A.