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STAFF RESEARCH PAPER

# Whole-of-economy modelling: beyond the black box

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# Preamble

One of the legislated functions of the Queensland Productivity Commission is to conduct self-initiated research on productivity, economic development or industry in Queensland. This is a staff research paper, aimed at informing rather than prescribing policy solutions. The views expressed in this paper reflects those of the author and may not represent the views of the Queensland Productivity Commission.

The paper benefited from feedback provided by the Centre of Policy Studies at Victoria University and by members of Queensland Treasury's modelling team.

## About the Queensland Productivity Commission

The Queensland Productivity Commission is an independent statutory body that provides policy advice on complex economic and regulatory issues.

The Commission has an advisory role and operates independently from the Queensland Government—its views, findings and recommendations are based on its own analysis and judgments.

Further information on the Commission and its functions can be obtained from the Commission's website www.qpc.qld.gov.au

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## Key points

- Economic impact modelling can add enormous value to decision-making by shedding light on the costs and benefits of policies, events and projects requiring public support. It can identify the winners and losers from economic change and help build support for difficult policy decisions.
- For modelling to be useful, it must provide credible evidence to inform debate. Too often, practitioners have attempted to win favour with decision-makers by skewing modelling results to match a preferred, pre-determined outcome. This misuse undermines the credibility of modelling, and means that decision-makers (and the public) do not have access to a valuable tool to inform policy debate.
- This paper provides guidance material on economic impact modelling—what it is, what it can do (and what it cannot do), common modelling mistakes and misuses, techniques for understanding the validity (or otherwise) of modelling results, and some advice on best practice. It is hoped that it will assist decision-makers to make more informed choices when commissioning economic modelling and derive better value from economic modelling studies.
- For whole-of-economy modelling exercises, a computable general equilibrium (CGE) model is generally the most appropriate type of model. Input–output modelling should not be used for undertaking economic impact assessments.
- Where a simple analysis is needed, or CGE modelling is considered too costly, only the direct impacts should be assessed. Indirect or flow-on impacts should be considered qualitatively.
- CGE models are flexible tools, as the assumptions on which they rest can be. This feature increases their usefulness, but leaves them open to misuse (intentional or otherwise). Understanding these assumptions is critical to making an informed assessment of any modelling exercise.
- Key assumptions to consider include:
  - how labour markets respond to change
  - how modelling accounts for project financing
  - whether opportunity costs have been fully accounted for.
- When reporting modelled outcomes, it is best practice to:
  - publicly release reports for review and assessment
  - provide technical attachments outlining all assumptions used in the modelling, to allow for independent review and assessment
  - include of a range of economic results, with per capita real income reported as the headline indicator of economic welfare
  - provide appropriate sensitivity testing of key, or controversial, assumptions.
- The results from whole-of-economy modelling are rarely the only consideration for policymakers. Often, the main benefit from modelling is that it highlights the economic costs of a project, policy or reform that provides other social benefits. This allows decision-makers to understand and consider the economic consequences of their decisions and make more informed public policy.

# 1. Introduction

This paper provides guidance for users of economic modelling. It is written for the non-modeller, particularly those seeking to better understand the results and validity of modelling reports. For those seeking to commission economic modelling, it contains useful guidance material for conducting economic modelling.

The paper aims to improve the contribution of modelling to public policy debates.

Economic modelling can be a powerful tool to build consensus for change. Done well, it can better inform policymakers on the costs and benefits of implementing new policies, events or projects. However, concern is growing that poorly conceived economic modelling is increasingly making its way into the public policy debate.

Poor modelling has the potential to mislead decision-making (and impose costs on society). It also undermines the credibility of economic modelling, and threatens to turn decision-makers away from a valuable tool for policy analysis.

## 1.1. When whole-of-economy modelling is needed

Where public funds are used to subsidise a subsection of the economy (such as through an industry-specific subsidy, industry-attraction program or the provision of infrastructure), it is particularly important to understand the broader economic impacts. In effect, these types of investments are made by governments on behalf of taxpayers. Both government and taxpayers need to be assured that these public investments are worthwhile, and will generate net benefits by creating sufficient employment, income or other benefits to justify their cost (Crompton et al. 2001).

Cost–benefit analysis is the predominant approach for assessing public expenditures. The approach assesses the costs and benefits of the project or policy, including market and non-market impacts.

Whole-of-economy modelling can be used as a complement to cost–benefit analysis. In general, it is not a substitute. Where it is used in cost–benefit analysis, some care needs to be taken to make sure the modelling approach is consistent with the cost–benefit framework.

Whole-of-economy modelling considers both the direct and indirect effects of policies, events or projects, and is used where the economic costs and benefits need to be considered from a whole-of-economy perspective, rather than from a narrow or sector-specific perspective.

A whole-of-economy perspective may be needed because policymakers want to understand:

- how reforms that have short-term costs might deliver long-term benefits
- whether policies that directly affect a small group of individuals are offset by small benefits or costs accruing to a majority
- the impact of policies, infrastructure or events on economic growth and economic welfare more broadly.

Computable general equilibrium (CGE) modelling has become the predominant economic modelling framework for conducting whole-of-economy analysis, and has been used to inform a wide range of policy debates at the state, national and global level.

As such, this paper has a strong focus on the CGE modelling framework.

## 1.2. The need for guidance on economic modelling

For the layperson, whole-of-economy modelling is complicated. Models are often composed of many thousands (or even millions) of obscure-looking equations. This inherent complexity means that models can be seen as 'black boxes' that are not easily understood.

This complexity means whole-of-economy models are open to abuse—either deliberately or through inadvertent error.

> *There are several points in an analysis at which different procedures and underlying assumptions can be made that will substantially affect the final result. Sometimes a genuine lack of understanding of economic analysis and the procedures used in them leads to inadvertent errors, but in other instances, they are used mischievously or strategically to deliberately mislead and generate large numbers. (Crompton et al. 2001, p. 80)*

Unfortunately, there are substantial incentives to use economic modelling to exaggerate benefits or to legitimise the position of a proponent. After all, a modeller who produces results that are not in their client's interest is unlikely to get repeat work. The difficulty for the layperson to understand or assess the validity of complex modelling results only exacerbates these incentives, because it allows the modeller to avoid scrutiny.

Economic modelling has come under increasing criticism in recent years, with poor modelling causing many to question its validity or usefulness:

> *Modelling is stupid, more often than not. And I'm not alone in thinking so...I'm much more in favour of backing intuition that comes from real-life experience. (Mitchell 2017)*

While this view may seem reasonable given the ease with which modelling can be misused, the alternatives are much worse.

It is important to understand that intuition involves a form of modelling. However, the intuitive model is not formal, and may exist in a decision-maker's head or scribbled on the back of an envelope.

The key difference between informal and formal modelling approaches is that formal modellers must be explicit about their assumptions and data (which are open to outside criticism), while the those arriving at conclusions based solely on intuition keep their assumptions and data to themselves.

Often perceptions about the opaqueness of formal modelling stems from a lack of transparency about the key assumptions used and how results were arrived at, rather than the complexity of the modelling itself.

> *[B]ad economic modelling is relatively easy to identify if readers are willing to ask themselves, and the modeller, a range of simple questions. Indeed, it is even easier to spot when the modeller can't, or won't, answer such simple questions. (Denniss 2012, p.1)*

In other words, a lot can be done to improve the transparency of modelling and thereby the user's confidence in it.

When modelling is done well, it should help the public debate by breaking down complex problems into simple metrics and allowing interested stakeholders to understand them and participate in policy debates. However, when modelling is done poorly, it only serves to stifle debate and muddy decision-making:

> *No matter which evaluation tool is used, its truthfulness and hence usefulness hinges on the government's commitment to sound, evidence-based policy. Otherwise these tools act as fig leaves for politically motivated investment decisions. Fostering a culture of analytical rigour and disinterested infrastructure policy should be high on the agenda for every government seeking to maximise social welfare. (Henckel & McKibbon 2010, p. 8)*

# 2. Whole-of-economy modelling

## 2.1. Partial equilibrium versus general equilibrium

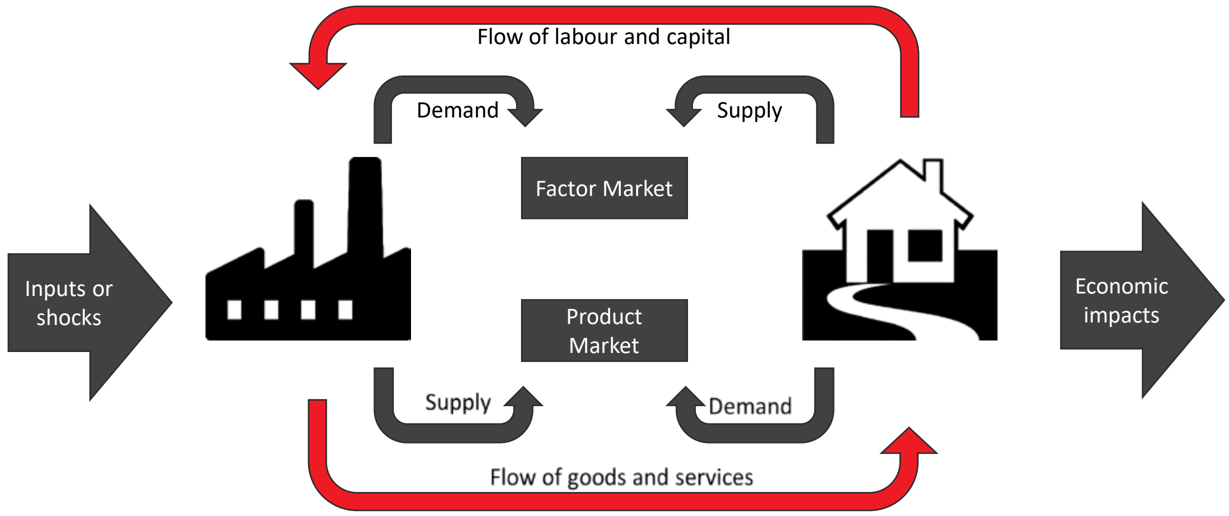
Economic modelling typically falls into two categories: partial equilibrium and general equilibrium approaches.

A partial equilibrium approach considers impacts only from the perspective of those who are directly affected. For example, a partial equilibrium model might consider how farm subsidies might increases farm production and profits. These models are generally reasonably simple, although they may consider a large amount of detail for the sector of interest.

A general equilibrium approach, on the other hand, attempts to consider economic impacts from the perspective of the wider economy (Figure 1). For example, a general equilibrium model would consider the impact of farm subsidies on farm production, but would also consider how government expenditures on subsidies might affect the rest of the economy. In that case, the modelling might consider how the increase in farm production would affect downstream industries, how the reallocation of resources (such as higher employment in agriculture) would affect other industries and how the subsidies are paid for (such as through increased taxes or reduced expenditures elsewhere).

Often the outputs from a partial equilibrium model are used to construct inputs for use in a general equilibrium model in order to estimate whole-of-economy impacts.

**Figure 1 A simplified general equilibrium approach**



## 2.2. The most common modelling approaches

Three main whole-of-economy modelling approaches are used in Australia:

- simple input–output analysis
- input-output econometric (IOE) modelling
- computable general equilibrium (CGE)—also known as applied general equilibrium (AGE)—modelling.

While other approaches can be used, these are the approaches most commonly applied to public policy in Queensland and Australia (Queensland Government Statistician's Office 2012).

### Simple input–output multipliers

Input–output (I-O) analysis uses a mathematical technique to estimate an economic 'multiplier' that describes the extent to which an industry is interconnected with the rest of the economy. In the past, I-O multipliers were commonly used to estimate the economy-wide impacts arising from direct firm or industry impacts.

However, the use of I-O multipliers has largely fallen out of favour, as their inherent simplifying assumptions became recognised as making them unsuitable for estimating economic impacts. The I-O shortcomings include:

- a lack of supply-side constraints—there is an implicit assumption that there is an infinite supply of labour and capital, meaning that output can be expanded without affecting other areas of the economy
- fixed prices—prices do not respond to increases (or decreases) in output
- fixed ratios for intermediate inputs, production and consumption—agents' behavioural responses are 'fixed; that is, they do not respond change by modifying their behaviour, rather continuing to produce and consume goods in fixed proportions
- absence of budget constraints—household and government consumption responses are not subject to budget constraints.

According to the Australian Bureau of Statistics:

> *While I–O multipliers may be useful as summary statistics to assist in understanding the degree to which an industry is integrated into the economy, their inherent shortcomings make them inappropriate for economic impact analysis. These shortcomings mean that I–O multipliers are likely to significantly over-state the impacts of projects or events. (ABS 2016)*

Despite these shortcomings, there remains misconceptions amongst some users that I-O multipliers are suitable for use in selected circumstances (Box 1). However, there are a few, if any, cases where I-O multipliers can provide any useful economic impact analysis in a public policy context. As noted by Banks (2002, p. 8):

> *[A trap into which proponents] often fall is the superficial appeal of 'multipliers'—the seeming science by which investment ripples are transformed into tidal waves of economic activity. In reality, the science of multipliers is the economics of the free lunch.*

In the vast majority of cases, the usefulness of I-O multipliers is likely to lie in understanding how deeply an industry is linked into the rest of the economy and how this might directly affect local supply chains, rather than in understanding economic impacts or the costs or benefits of projects, policies and events.

## Box 1 Common fallacies about input–output multipliers

It is commonly argued that is reasonable to use I-O multipliers in the following cases:

- There is slack capacity in the economy—while the existence of spare capacity limits the need to account for supply-side capacity constraints (one of the key weaknesses of I-O multipliers), it rarely means that there are *no* constraints. For example, skilled labour tends to remain in demand, even during downturns, and finance is never free. I-O multipliers do not account for any constraints, nor can they be 'adjusted' to account for the extent to which there is slack capacity in the economy.
- The region of interest is small—a common argument is that it is reasonable to apply I-O multipliers in small regions since it is possible to import any required labour or capital into the region from outside. While this may be true, estimating economic impacts would require that the changes in income flows (such as from wages accruing to fly-in fly-out workers or returns to capital owners living outside the region) are fully accounted for. I-O multipliers cannot do this.

  Multipliers that have been calculated from national or state I-O tables are not suitable for use in regions. Multipliers estimated from national or state-level I-O tables reflect assumptions about production capacities at the national or state level that do not hold in smaller regions.
- The direct impacts are only small—the argument put forward by proponents of I-O modelling is that where direct impacts are small, there will be little change in demand for inputs or labour and therefore no impact on prices (meaning we do not have to worry about the limitations of I-O multipliers). While this argument can be appealing, it is a 'fallacy of composition'. That is, while it may seem that a single small change would not impact prices, a lot of small changes, when combined, clearly would. The reality is that even small changes have an impact at the margin, and these need to be accounted for in economic modelling.

## Input–output econometric (IOE) modelling

IOE modelling extends the simple input–output framework by integrating econometric relationships that have been determined using time series or panel data. By incorporating these relationships, the IOE model is able to include some supply-side constraints.

One key limitation of the IOE model is the lack of detailed historical data, particularly for regions, which is required to determine the supply-side relationships. Another is that the simple structure of the IOE models[1] means that the models are only suitable for a very narrow range of modelling tasks. These issues have limited the use of IOE models in practice.

[1] For example, IOE models do not include price effects.

## Computable general equilibrium (CGE) models

CGE models use a highly disaggregated database constructed from Australian input–output tables (ABS 2016), combined with a series of equations to ascribe behavioural rules that determine the way the various economic agents respond to change. Typically, these behavioural rules are neo-classical in spirit, assuming cost-minimising behaviour by producers, welfare optimising by households and an equilibrium of supply and demand, which is determined by changes in relative prices.

The models' behavioural rules are derived from economic theory rather than from time series data[2], allowing them to overcome the practical difficulties associated with IOE modelling and the limiting assumptions inherent in I-O multiplier analysis (Horridge 2014). By focusing on the structure and detail of agent-specific behaviour, they also allow the CGE models to capture detailed economic relationships and connections that would be missed in econometric modelling exercises that are reliant on extensive historical data sets.

CGE models are complex, with many thousands (or even millions) of equations. This complexity allows the models to be applied to a wide range of 'what if' questions, but also allows users a wide scope in determining the assumptions they use.

Over the last decade, CGE modelling has replaced other simpler forms of modelling, largely because of its flexibility of approach, the availability of data, and its ability to account for resource constraints. Software improvements and training have also greatly reduced barriers to entering the field, and today CGE modelling is the preferred approach for economic impact analysis (Gretton 2013); many government guidelines[3] also recommend its use.

Given the widespread use of CGE modelling over other approaches, the remainder of this paper is largely devoted to the CGE modelling approach.

A brief technical description of CGE models in provided in Box 2.

## Other modelling approaches

**Dynamic stochastic general equilibrium (DSGE) models**

DSGE models are dynamic (studying how the economy evolves over time) and stochastic (based on historical time series data), and they use theoretical constructs (that may be based on economic theory rather than direct observation) to overcome some of the limitations of pure econometric models.

DSGE models were designed to assist central banks and other financial actors to better forecast future economic activity. The approach has attracted a lot of criticism in recent times, largely because financial firms using the modelling failed to foresee the global financial crisis.

The use of DSGE models is predominantly for forecasting macroeconomic conditions. They typically have little use as a tool for policy analysis because of their limited industry detail.

**Supply chain models**

Supply chain models are used by firms to provide oversight of materials as they move from supplier to the final user. They are not suitable for undertaking economic impact analysis.

[2] The parameters used in these behavioural rules are usually inferred from observation, although these can be informal.
[3] Including the Queensland Government's *Project Assurance Framework* and *Program Evaluation Guidelines.*

## Box 2 Brief description of a typical CGE model

The many variants of CGE models range from small national models to very large regional models that can examine complex policy issues. Nevertheless, at their core, they share a range of key common features.

- Assumptions are neoclassical—demand and supply equations for agents (households, investors, producers and foreigners) are derived from optimisation problems that assume agents engage in cost minimisation, utility maximisation and profit maximisation. In general, agents are assumed to be price-takers, producers are assumed to operate in competitive markets, which prevent the accumulation of economic profits[4], and markets are assumed to clear.[5]
- Factor constraints are appropriately accounted for—for example, capital is assumed to take some time to build, with investment responding to changes in rates of return on existing capital. Labour markets are typically assumed to respond slowly to changes in demand, with lags between impacts and wage responses. Capital and labour are assumed to be weakly substitutable.
- Interactions are derived from data—the model's core data is based on input–output data, which provide a very detailed 'snapshot' of the Australian and regional economies, including inter-industry and commodity-specific trade flows; consumer, government and investor purchases; and industry-specific inputs (ABS 2016). A number of satellite accounts are also typically used. These include government finance accounts, household income accounts, capital accounts and other supplementary, or non-market, accounts such as for population and demography, and energy and greenhouse gas emissions (Adams et al. 2015).
- The model equations are typically written in linear, 'per cent change' form. This aids model interpretation and allows the model form to be simplified. Non-linear solutions are developed using multi-step solution techniques—these are usually performed using complex mathematical procedures in software such as GEMPACK (see Horridge 2014).

For those interested in more technical detail, a wealth of information, including downloadable versions of some Australian models, is available at www.copsmodels.com.

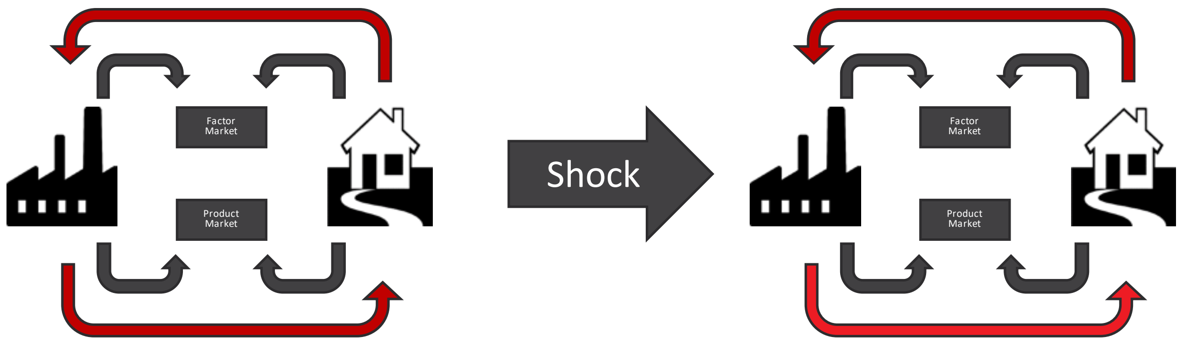
[4] Economic profits are profits earned after opportunity costs are fully accounted for. For capital, opportunity costs reflect the risk-weighted market rate of return.
[5] Most dynamic models have the capacity to deal with market imperfections. For example, most dynamic models allow for excess supply conditions to hold in labour markets.

## 2.3. Comparative static versus dynamic modelling

The difference between comparative static and dynamic modelling relates to the treatment of time.

Comparative static modelling has no explicit treatment of time (Figure 2). Rather, the model compares one equilibrium state with another. In practice, this is done by applying a shock to the model and comparing the old economy with the new one. The impacts are, effectively, the effects of the shock with all other things held fixed. Although the model can be used to consider the impacts from a ‘short-run’ or a ‘long-run’ perspective[6], the model does not explicitly consider the evolution of economic changes through a sequence of points in time.

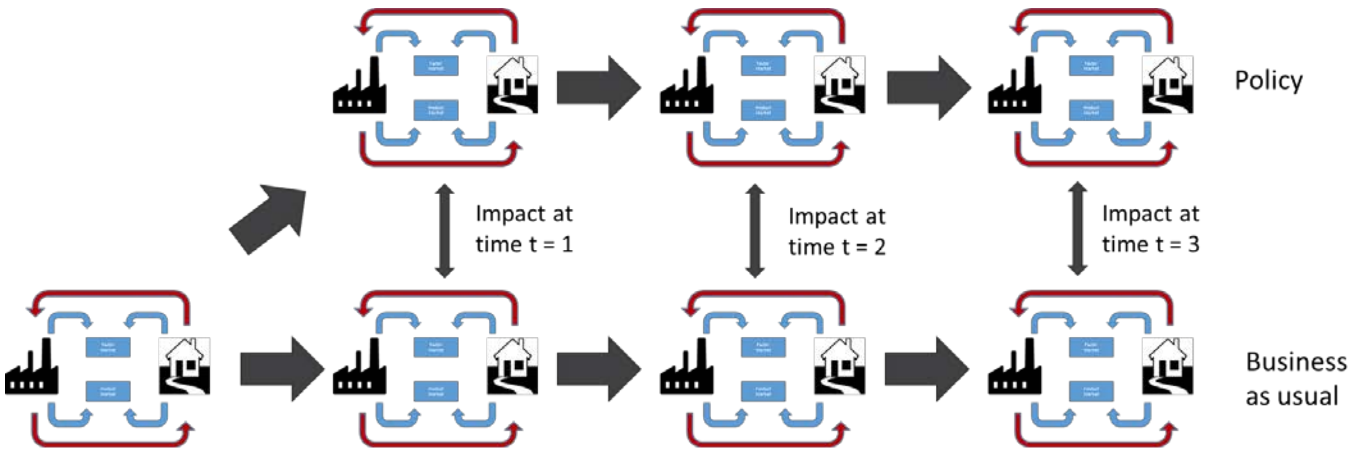
**Figure 2 A comparative static approach**




Impact = economy at state 1 less economy at state 2

The dynamic approach, on the other hand, includes an explicit treatment of time (Figure 3). It does this by first developing a base case—a business as usual growth path for the economy—and then running an alternative case with the policy, event or project in question included. The impacts are estimated by comparing the economy’s new policy-induced growth path with the base case, and can be calculated for each year of the simulation.

**Figure 3 The dynamic approach**




[6] In comparative static modelling, certain variables that reflect the way the economy adjusts over time are held fixed or are allowed to adjust, depending on the assumed time frame. For example, it might be assumed that in the short run, capital stocks cannot adjust immediately in response to a shock, and that certain nominal rigidities (like the wage) hold. In the long run, it might be assumed that rates of return revert to an equilibrium rate as capital stocks adjust to the initial shock.

Typically, dynamic models allow for the changes in the capital stocks and the accumulation of net foreign liabilities.[7] Dynamic models can therefore account for any changes in borrowings or equity required to fund domestic activities, with subsequent impacts on domestic incomes.

Dynamic models also allow for more realistic market settings such as the gradual adjustment of wages and employment by introducing lags to wage bargaining (the sticky wage assumption).

These features allow the dynamic model to consider how the economy might adjust to the shock over time, with results produced for each year of the simulation.

## Box 3 Is dynamic modelling worth the effort?

Dynamic modelling, where the time path of economic adjustment is explicitly modelled, is more complex and more expensive than static modelling. The right approach depends on several factors. For example, the added expense of a dynamic approach may be justified where:

- the adjustment path is likely to impose significant costs or benefits (or there is significant uncertainty about this path)
- the economy or sector of interest is undergoing rapid change, meaning there is some uncertainty about whether impacts in today's economy will be the same in the future
- it aids interpretation or messaging—for example, Dixon et al. (2013) demonstrate that dynamic modelling can help consumers separate out the effects of policy change from other factors, particularly for industries that are already in decline
- the simulation involves significant capital investments—because most comparative static modelling approaches cannot endogenously (within the model) account for shifts in the foreign ownership of capital, which can limit their use for capital intensive projects[8]
- impacts are expected to take a long time to take effect.

A relevant example where dynamic modelling is useful relates to proposed company tax cuts. Understanding the time path of impacts is crucial, since impacts are expected to take around 20 years to take effect (Kudrna & Woodland 2010) and the cuts are expected to reduce real income when they are first implemented, with benefits taking some time to accrue (Minifie & Chisholm 2017).

Indeed, modelling conducted by the Centre of Policy Studies at the Victoria University (Dixon & Nassios 2016) shows that the adjustment path is crucial to determine if company tax cuts provide net benefits or costs.

A dynamic approach can be essential for many policy analyses, since it can be used to construct estimates of the net present value of welfare changes, allowing various options to be compared.

[7] Net foreign liabilities are the sum of net foreign debt and net foreign equities, reflecting changes in foreign borrowing and foreign ownership required to fund domestic activities (plus any changes to the valuation of debt and equity).
[8] It is possible to overcome this limitation by making post-modelling adjustments to account for changes to foreign ownership.

## 2.4. What can it be used for?

Whole-of-economy modelling is most commonly used where policies, events or projects are expected to have large impacts on the economy, particularly when there are likely to be significant indirect impacts or a range of winners and losers.

Often policies or projects have large impacts on a small sector of the economy but small impacts on many other sectors. In such cases, it can be enlightening to use whole-of-economy modelling to determine net economic costs or benefits.

Whole-of-economy modelling can be used to build a case for policy intervention or, where there may be significant costs on some sectors, a case for industry adjustment measures. It can also be used to estimate the costs (and benefits) of removing industry support measures and assist policymakers to understand the extent to which some sectors of the economy might be affected by change.

CGE models have been used to estimate whole-of-economy impacts for a wide range of policy debates, for example:

- tax policies, including the introduction of the GST and changes of tariff rates
- environmental policies, including emissions trading, carbon taxes and renewables targets
- infrastructure projects, particularly where these are likely to result in significant impacts on productivity or demand
- sporting events, including the Sydney Olympic games
- the introduction of market-led rationing, such as the water trading regimes in the Murray Darling basin
- labour market reforms.

The framework can also be applied as a forecasting tool and for conducting historical analyses; however, these aspects of CGE modelling are beyond the scope of this paper.

## 2.5. CGE modelling and cost–benefit analysis

Cost–benefit analysis (CBA) involves a comprehensive assessment of all the costs and benefits associated with proposed project options, including financial, environmental and social costs and benefits (Queensland Treasury 2015). It is used to weigh up options, including a do-nothing option, to determine the best course of action.

Depending on the size and scope of the project in question, a CBA may consider benefits and costs from a narrow (firm or industry) or broad (economy-wide) perspective. It may also be simple or complex, depending on the nature of the project being considered.

For most CBAs there is no need for whole-of-economy modelling, and impacts are assessed using a partial equilibrium model. For example, for a new road project, the benefits may be assessed through a traffic model that estimates the time savings the road will generate. These savings can be monetised and compared to the cost of building the road, to determine whether the road should be built or whether there are better options.

However, sometimes a broader, whole-of-economy analysis is required. This might be the case where reforms or policies have broad impacts and the beneficiaries are different from the funders—such as the implementation of an emissions trading scheme—or where public funds are used to assist industry. In these cases, a CGE model can be used to provide inputs into the CBA.

If CGE models are used in CBAs, a few issues need to be considered:

- scope issues—CGE modelling is concerned only with market (monetary) impacts; a CBA generally includes social, environmental and any other non-monetary impacts, which generally[9] need to be considered outside of the CGE model
- treatment of costs—the CGE modelling needs to treat costs in a way consistent with the CBA approach. Under a CBA, construction expenditures are treated as a cost, reflecting the opportunity cost of funding the project[10]
- welfare, which is the key indicator of benefit for a CBA—some consideration would need to be given to constructing appropriate measures in the CGE model (see Box 4).

## Box 4 Measuring welfare—CBA versus CGE

CBAs are concerned with measuring welfare. The monetary components of welfare are typically measured by estimating changes in consumer and producer surplus using well-established methods. Government surpluses are typically also included, since they accrue to households through tax savings or additional services.

CGE models are typically associated with economic indicators such as GDP, household consumption and income, which are different from welfare. However, CGE models have a set of demand and production functions, and (usually) explicit treatment for government surpluses from which welfare measures can be estimated.

In cases where economy-wide impacts are important, the CGE model may provide a more robust welfare measure than a standard CBA because of its general equilibrium capabilities. For example, large projects may result in a shift in the terms of trade, with subsequent effects on welfare—a CGE model can estimate changes to the terms of trade (and its effects on welfare), while a traditional CBA that only considers direct effects cannot.

[9] CGE models can be constructed to include non-market values. For example, the CGE model outlined in Adams et al. (2015) includes carbon and energy accounts and Wittwer and Dixon (2013) include water accounts.

[10] While a construction project may make a contribution to economic growth, a good economic impact analysis should consider the source of these funds and any opportunity costs their use entails. For government expenditures this might include an allowance for borrowing costs or the effect of increased taxation.

## 2.6. Limitations

Although whole-of-economy modelling can be a powerful tool to facilitate evidenced based policy development, users should be aware of the key limitations inherent in most models (including CGE models).

Key limitations include:

- The model is an aid to good economic analysis, not a substitute for it.
- Modelling is a simplification of the real world and may need to be supplemented by more detailed partial equilibrium or qualitative analysis.
- Very often, key modelling parameters will be unknown or difficult to estimate—for this reason, it is crucial to identify and make explicit those variables where uncertainty exists, and to test how sensitive the model results are to key parameter changes.
- The complexity and level of expertise required can make robust whole-of-economy modelling relatively expensive.
- Typically, CGE models do not include a treatment of financial markets—this means that risk-related borrowing costs, monetary policies and other financial market behaviours are not determined in the model, and need to be imposed exogenously, reflecting the modeller's judgement rather than any pre-determined modelling rules.[11]

[11] There are exceptions to this rule, such as the G-cubed model developed by McKibbon and Wilcoxen (1995), which includes intertemporal counting of stocks and flows of financial assets and integrates real and financial markets.

# HOW MODELLING IS MISUSED

Done well, whole-of-economy modelling can provide useful insights into public policy, help to inform debate and build consensus for change. Done badly, modelling can misinform and muddy the waters, slow down needed change and discourage future evidence-based analysis.

## The most common mistakes (intended or unintended)

### 1 Failing to specify the counterfactual scenario

Setting up the counterfactual (or business as usual case) is perhaps the most important part of any modelling exercise. The counterfactual determines the alternative use for resources, including labour, capital and government monies. Appropriate consideration of the counterfactual means that opportunity costs are fully considered. Failing to do so is likely to significantly overstate the impacts of the event, policy or project being considered.

### 2 Failing to properly account for financing costs

The financing for projects must come from somewhere. Unless projects are expected to increase domestic savings, any new borrowing needs to be funded (directly or indirectly) through increased foreign investment, or, for government-funded projects, increases in taxes. Failing to properly account for the income flows arising from new foreign investment or from government debt is likely to significantly understate the costs of a project (Dixon 2009).

### 3 Using assumptions that are not realistic

Economic modelling is a simplification of the real world. It will never be possible to know all information and there are many unresolved issues about the way the economy, and the agents within it, react to change. This means that economic modellers have a lot of flexibility regarding the assumptions they use. These assumptions can significantly influence the outcomes of the modelling. Choosing assumptions that are reasonable (or testing those that are unknown or uncertain) and making these clear to readers is essential to build credibility, and should be expected of any economic modelling exercise.

### 4 Reporting the wrong indicators

The most commonly reported measures are GDP and employment; however, these are often misleading indicators of economic welfare. Better indicators are those that relate to income. Similarly, where modelling allows changes to population (implied or explicit), failing to provide per capita results can mislead readers.

# 3. Assumptions and data

As discussed earlier, the primary approach for conducting whole-of-economy modelling in Australia is CGE modelling. For this reason, most of the discussion in this section relates to CGE modelling. Nevertheless, many of the issues discussed in this section are relevant for other modelling approaches.

## 3.1. The importance of the assumed economic environment ('closure')

CGE models are flexible tools that can be run using a variety of assumptions that determine how the modelled economy responds to change. These assumptions are known as the 'closure' (Box 5). The choice of closure is important as it can significantly influence the results of any modelling exercises. Although there may not be a single 'wrong' or 'right' closure for any individual modelling exercise, there are many choices that would be unsuitable or could provide misleading results if not presented carefully.

The flexibility of the CGE modelling approach provides advantages in that it makes the modelling adaptable for a wide range of uses. However, it also opens the modelling approach to misuse (intentionally or otherwise). For example, by setting up a certain closure, it is possible to assume that there are no constraints on the supply of labour and capital and that demand has no impact on prices.[12]

Understanding the assumptions behind the model closure, the reasons they are valid and the way they influence results is an important step in any modelling exercise. **Every modelling exercise should list the exact closure that was used so that readers can make sense of the results.** All assumptions should be listed, with technical detail provided as an attachment if needed.

### Box 5 The closure

CGE models are composed of numerous equations describing the behaviour of economic agents. Each equation in the model explains an endogenous variable (explained within the model). However, in the model there are more variables than there are equations. These 'surplus' variables cannot be explained by the model and are exogenous (they are determined outside the model, or do not change in response to a shock).

In CGE modelling, the modelling assumptions that determine the economic environment the model operates in is known as 'the closure'. The closure determines which variables are determined endogenously (within the model) which are determined exogenously (outside the model).

The economic environment, or closure, in a CGE model can be changed by 'swapping' the endogenous and exogenous variables in the model. These 'swaps' allow the modeller to change assumptions.

The simplest swap in a CGE model allows the modeller to move between a short-run and a long-run closure.[13]

[12] It is possible to run a CGE model with much the same limitations as an I-O multiplier.

[13] For example, it would be sensible to assume that firms cannot immediately change their capital stocks, and that rates of return will shift up or down in response to an economic shock. In the long run, however, firms can build or purchase capital stocks, and rates of return will return to normal as investors adjust to the economic shock. In modelling parlance, we move from a short-run closure to a long-run closure by swapping capital stocks with rates of return.

## 3.2. The importance of data

The data underpinning economic models is crucial. It lays the foundations for the relationships between the various actors in the model, and plays a key role in determining the transmission of the direct impacts on an industry or region to the rest of the economy. When the data is wrong or of poor quality, this undermines the accuracy of the modelling.

Data also works to undermine or support confidence in modelling. Stakeholders are often well-informed about the latest statistics that relate to their area or industry of interest. When they see conflict between the data in the model and what they know, this can undermine their confidence in the model's outputs.

It is important to construct accurate, detailed and up-to-date data sets so that accurate results are generated and confidence is built amongst stakeholders. Yet, it can be prohibitively expensive. Hence there are some important trade-offs to be considered when commissioning modelling services.

Perhaps the most important thing to keep in mind is that it is rarely possible to construct a perfect dataset for a whole-of-economy model. In part this is because there can be large inconsistencies between official data sets that only become apparent when they are confronted in a whole-of-economy model. These apparent data errors often arise because official data is constructed using survey instruments that are imperfect.

A whole-of-economy model is typically constructed from a range of data sources. These data must be reconciled against each other, and are often adjusted so that they are internally consistent within the model.

This means that expecting a whole-of-economy model to align perfectly with all official data sets is unrealistic.

However, even with this constraint in mind, it should be expected that the data in any whole-of-economy model should closely align with official statistics.

For those industries that are directly affected by the policy change or event, it is important for the model's database to reflect known industry data. For this reason, it is reasonable to request that the model data for selected industries be made available for scrutiny.

Where model data deviates significantly from official data, an explanation should be sought. There may be valid reasons for differences, including practical reasons, such as where data discrepancies are unlikely to result in significant error but would be unduly costly to resolve.

## 3.3. Recommended assumptions

The following sections lay out some of the key assumptions that are likely to be relevant for most common modelling exercises, and then suggests some approaches that could be used for different kinds of modelling exercises. The list is not intended to be comprehensive, as there are too many modelling permutations to list here. Nevertheless, this section discusses the main assumptions, distinguishes which ones are reasonable and provides an appreciation of why it is important to make these assumptions clear.

### Labour markets

The supply of skilled labour is not infinite and, outside of cyclical downturns, demand-side policies (such as stimulus programs) are unlikely to result in long-run gains in employment. As noted by Ken Henry (2007):

> *[W]e need to have an appreciation of the consequences of policy intervention in an economy operating at, or close to, full employment. In the absence of externalities and other sources of market failure … any government intervention will shift resources, including jobs, from one activity to another and impose a deadweight loss of efficiency on the economy…As a rather crude, but nevertheless instructive generalisation, there is no policy intervention available to government, in these circumstances, that can generate higher national income without first expanding the nation's supply capacity.*

This means that modelling should appropriately consider the current supply and demand conditions in the labour market, including any shortages of skilled labour and the extent to which this may constrain additional economic activity.

While unemployment rates vary considerably over time, these swings are mainly due to business cycle effects (such as the global financial crisis and the mining investment boom). In general, unless policies are directly targeted to addressing cyclical downturns, their efficacy or otherwise is best assessed in the absence of these business cycle effects.

This means that, unless the modelling exercise is examining a supply-side change, such as labour market reforms, the modelling should assume that the long-run rate of unemployment be fixed at the natural rate of unemployment (see Box 6) and that participation rates and national population remain fixed at their business as usual levels. That is, in general, it should be assumed that, nationally, the policy or event being modelled will have no effect on employment in the long run.

## Box 6 The natural rate of employment

One of the central tenants of economics is that there is a natural or structural rate of unemployment (or employment). This occurs because at any time a range of factors are constraining the ability of workers to move into employment.

For example, it generally takes a recently unemployed worker some time to train, seek and apply for a new job, it may not be possible for workers to easily move to new locations for work, and there may be a range of industrial relations conditions that constrain movement between jobs (Ballantyne et al. 2014).

A more technical name for the natural rate of employment is the non-accelerating inflation rate of unemployment (NAIRU). The NAIRU is the lowest sustainable rate of employment that is possible before inflation starts increasing. This means increasing demand for labour when the economy is at its structural rate of unemployment, without addressing any of the underlying causes of structural unemployment will, over time, only result in wage rises.

Evidence for the NAIRU can be seen in the labour market effects during the recent mining boom. During this period wage rates soared, putting upwards pressure on inflation. While the ramp-up in demand for workers caused unemployment to dip below 5 per cent for a short while, over time, wage pressures caused activity to slow in the non-mining parts of the economy forcing the unemployment rate back towards its normal, or structural, rate.

The IMF estimates that Australia's NAIRU is around 5.5 per cent (IMF 2015), and that, over the long run, demand-side measures (such as government-funded stimulus) will have little impact on employment.

## Interstate and interregional migration

For models with more than one region, consideration must be given to the role of interstate or interregional migration, and the way this migration responds to economic factors.

There is no single best or recommended approach, and various models use different assumptions and techniques for estimating migration.

For many modelling exercises, changes to labour demand are assumed to drive changes to migration—a rising demand for labour in one region initially lifts relative wages and drives a movement of workers towards the region. Over time, wage differentials disappear and the policy-induced migration ceases. For other modelling exercises, an increase in labour demand is assumed to have no effect on migration, instead causing an increase in the wage rate differential between regions.

The choice about how migration responds to the change depends on the policy or event being analysed. For example, a short-term event is unlikely to cause a shift in interstate migration, and so it would be sensible to choose a modelling option that reflects this.

Whatever option is chosen should be made explicit. Where the modelling choice is to allow migration, results should be reported on a per capita basis to avoid misinterpretation of costs or benefits. It is also best practice to report results for all regions in the model.

## Capital markets

Capital does not instantly appear, and it must be sourced from somewhere. Modelling should reflect this.

In the short run, the modelling should appropriately account for the level of capital stock and the extent to which these stocks constrain output. Consideration should be given to the time it takes to construct new capital (for example, it typically takes three or more years for a mine to become operational once construction starts) and the extent to which the existing capital stock is utilised.

The modelling needs to also consider how any new capital is obtained. If sourced from foreigners, this should be reflected in the future ownership, and profits should be repatriated to foreign owners.

Failing to account for changes to foreign ownership of capital may significantly exaggerate benefits, particularly for capital-intensive projects.

## Project financing

New projects can be financed by debt financing or through equity raising. The omission of key details regarding project financing can have significant impacts on results, particularly for infrastructure projects (Giesecke & Madden 2009).

Financing must either be raised offshore or from domestic savings. In general, it makes little sense to assume that a new project would increase the rate of domestic savings. Rather, the default assumption should be that projects do not change the level of domestic savings (either for use in debt financing or equity raising).

This implies that it is only possible to raise debt and equity financing from offshore. For this reason, the default assumption should be that the interest and income payments on the debt and equity components of a project's financing costs are repatriated offshore (see Box 7 for some technical detail).

Where debt financing is being used, some consideration needs to be given to the appropriate length of time to run the simulation to ensure that the accumulation of costs over time are properly accounted for.

As noted earlier, the majority of CGE models do not include an endogenous representation of financial markets. This means that unless specified otherwise, it is assumed that the policy, project or event has no impact on financial markets. While this is often a valid assumption (for example, small changes to borrowings are unlikely to affect ratings agencies, and the cost of government borrowing), it should be noted that the modeller will need to make his or her choices outside of the model framework.

Giesecke et al. (2008) provide some analysis which suggests the choice of financing arrangements can influence welfare outcomes—this analysis, however, is complicated and the issues it raises are beyond the scope of this paper.

## Government budget balancing—public inputs need to be treated as costs

Where governments fund projects, these costs need to be accounted for in some way. Government expenditure on a project, event or policy must be funded in one of three ways:

- reducing other government expenditures
- increasing taxes
- undertaking additional borrowings, which will need to be paid for in the future (either by increasing future taxes or reducing future expenditures).

It is generally best practice to fully account for project or policy costs over the simulation period, since this allows the true costs and benefits of policies, events or projects to be considered by decision-makers.

While it is often the case that government borrowings will mean that projects are paid for over very long periods of time, this does not provide sufficient reason for not including the cost of borrowings in the modelling exercise. On a net present value basis, there should be only relatively minor differences[14] between the economic costs of projects that are funded upfront versus those that are funded through borrowings. Failing to account for the full cost of government borrowing can make modelling results misleading, since the impact of this borrowing on future incomes would not be fully accounted for.

For policies or projects involving current expenditure, a common approach is to hold government budget balances fixed as a share of GDP or GSP, and allow tax rates to adjust. There are a number of different tax rates that can be used to balance government budgets, but the best approach is generally to choose a tax rate that is the least distortionary. Often a quasi-tax, such as a costless transfer to households, is used in order to avoid a focus or debate on the pros and cons of a specific tax.

[14] Giesecke et al. (2008) argue that, under certain conditions, there are benefits to debt funding since it can allows for a closer match between the timing of benefits and the burden of financing the infrastructure.

## Box 7 Accounting for project debt and equity financing

It is important to ensure that project financing is appropriately accounted for. Where projects are financed through equity or debt, these financing costs should be explicitly represented in the model.

New financing for projects most often needs to be sourced from offshore. This foreign debt and equity must be accounted for in the model. A technical description for accounting for the repatriations to foreigners in any given year (t) is provided below:

$$\begin{aligned} REPATRIATIONS_t & \\ &= \left(\left[\sum_{t=1..n} INVESTMENT_t\right] \times SHARE_{debt} \times RATE_{debt}\right) \\ &+ \left(PROFIT_t \times (1 - TAXRATE) \times OWNSHARE_{foreign}\right) \\ &+ \left(\left[\sum_{t=1..n} INVESTMENT_t\right] \times SHARE_{equity} \times OWNSHARE_{domestic} \times RATE_{foreign}\right) \end{aligned}$$

where:

SHARE = share of equity or debt

OWNSHARE = the ownership share, where owners can be domestic or foreign

$RATE_{debt}$ = rate on debt

$RATE_{foreign}$ = average rate of return on foreign equities

The first term in the equation represents the debt-funded proportion of the financing and is the cost of the investment by the proportion that is debt funded by the rate on debt.

The second and third terms represent the equity-share of the financing.

The second term accounts for repatriations to foreign equity owners, and is equal to the after-tax profit by the share of foreign ownership.

The final term represents the opportunity costs of domestic investment in the new project. With a fixed saving rate, any new investment by domestic residents must come through a reduction in investments made offshore. This opportunity cost is estimated as the domestic funds invested by the average rate of return on foreign equities.

The net income accruing to domestic residents arises from the profits on capital and returns to labour, less repatriations made to foreigners. The benefits to domestic residents will depend on the profitability of the investment, the tax rate applied to the foreign owners of capital and the domestic owner's share of the new investment.

Source: adapted from Giesecke & Madden (2009).

# 4. Specific types of analysis

This section provides guidance material for some specific types of analysis. This guidance is intended to illustrate best practice approaches, and highlight potential pitfalls for a few common types of modelling exercises. The examples provided suit the circumstances specific to the projects in question, and may not suit other projects or apply to them directly. Nevertheless, the examples have been selected because of their broad applicability.

## 4.1. Infrastructure projects

It is common for large infrastructure projects to be accompanied by an economic impact study. This may be because a private proponent is motivated by the need to seek an environmental or regulatory clearance, or is seeking public assistance to bring the project to fruition. For governments, economic impact analysis may be needed to justify public expenditures, particularly where the result is likely to be broad economic impacts that cannot be captured in partial equilibrium approaches.

The most appropriate way of assessing infrastructure projects is through a CBA (see Queensland Treasury 2015 for guidance). CGE modelling, however, can be used as part of a broader cost–benefit study (Forsyth 2014), but must be consistent with the cost–benefit approach.

Two key impacts are typically assessed when modelling infrastructure projects. The first relates to the impacts arising from the additional activity during the construction phase. The second relates to the medium- to long-term effects that infrastructure has on increasing access to markets, reducing living costs, increasing efficiency, and in facilitating specialisation and economies of scale. Under a cost-benefit approach, it is the latter impacts that are most important, however, it is often on the former that modelling is most often poorly conceived.

For this reason, it is recommended that the construction phase of the project is modelled and reported separately from the operational phase. This will aid interpretation, and help avoid common mistakes made in the modelling of infrastructure projects.

In relation to the construction side of the project, the most common mistake is that proponents do not properly account for the opportunity costs of the funding used for construction. All modelling needs to recognise that large capital works projects use scarce capital, labour and project financing that constrains activity elsewhere in the economy.

These constraints need to be properly accounted for, with assumptions reflecting real-world conditions.

A critical, but challenging constraint is the financing arrangements. A well-constructed modelling approach should appropriately consider the financing arrangements, including checking that:

- any government borrowings are appropriately accounted for
- any increase in financing increases foreign liabilities, with appropriate accounting for future foreign debt and/or equity payments
- the modelling timeframe is long enough to capture the full costs of any debt or equity funding.

See section 3.2 for more detail on issues relating to the financing of projects.

## 4.2. General government expenditures and subsidies

It is common for government to seek to understand how expenditures they make or subsidies they provide will impact on the broader economy. Like infrastructure projects, there are two types of impacts—those arising from the fiscal stimulus associated with the expenditures, and those arising from the policy itself.

While it can be useful to understand the stimulus effects arising from government expenditures, careful consideration needs to be given to:

- how expenditures or subsidies will be funded—options include increasing taxes, reducing other expenditures or increasing debt
- the time frame that simulations need to be run to provide a meaningful net present value estimate—particularly where debt instruments are used
- any consequences for financial markets—economic impact models (like CGE) typically do not include financial markets; therefore, they do not factor in how government borrowing might affect confidence or debt rating.

Where the opportunity costs of government expenditures have been appropriately accounted for, readers should expect that net economic impacts from fiscal stimulus will be negligible.[15] Instead, the focus and main impacts of the modelling should arise from the implementation of the policy or project in question.

## 4.3. Industry assistance

It is worth making some mention of industry assistance policies, given the controversy they entail and the range of winners and losers they typically involve.

All states and territories spend large sums of money on industry assistance measures of one type or another. The rationale for providing this industry assistance varies, and can be to encourage economic growth and employment, stimulate innovation and skill development, or meet other social objectives.

The key to understanding whether industry assistance measures provide net economic benefits is in being able to quantify the costs and benefits they impose on the rest of the economy.

Tariffs are a good case in point. Prior to reforms in the 1980s, Australian manufacturing was heavily protected by a system of quotas and tariffs. While this system provided obvious benefits for manufacturing firms protected from foreign competition, it also undermined the competitiveness of other firms and increased costs for domestic consumers. Queensland, with its low manufacturing base and high reliance on trade-exposed industries like agriculture was particularly exposed to the costs of protection.

Whole-of-economy modelling was used to highlight the costs associated with Australia’s system of tariffs and import quotas, and to demonstrate that trade liberalisation would deliver net economic benefits. Importantly, the modelling was also able to identify the winners and losers from policy change, and help quantify the extent to which transition measures would assist economic outcomes.

The introduction of new industry assistance is likely to provide benefits to those industries or firms that directly receive assistance, but is likely to impose costs on other firms.

[15] There may be large effects on particular sectors, depending on how the policy or project is funded; however, the net effect across the economy should be small. The exceptions can be when there are significant idle resources (such as may arise during an economic downturn).

Modelling conducted by the Queensland Competition Authority suggest that, while some assistance measures provide net benefits, in aggregate, they impose net costs on the broader economy (QCA 2015). Indeed, this modelling estimated that, in aggregate, Queensland industry assistance measures reduce welfare by around $100 per person, annually.[16]

This suggests that, when considering new industry assistance, it is important to understand and quantify any indirect costs associated with the new measures.

While the strength of whole-of-economy models like CGE is that they consider indirect costs, there are many options that can be chosen when modelling these costs. This means that some assessment of the specific mechanisms by which the economic impacts are transferred through the economy need to be made.

Banks (2002) argues that the following factors should be considered when modelling industry assistance:

- any market failures that the industry assistance package is trying to address
- the extent to which any induced activity is likely to crowd out existing economic activities
- the nature of the local labour market, including the extent to which skilled labour exists to fill demand created by any induced activity
- the complementarities between skilled and unskilled labour, and the extent to which these may constrain the take-up of unemployed, low-skill workers
- whether subsidies to overcome a locational disadvantage reduce overall productivity by encouraging activity in regions without a natural competitive or comparative advantage
- the possibility of retaliatory behaviour by other jurisdictions
- the extent to which ongoing subsidies are required.

Some thought may also need to be given to the difficulties associated with making industry assistance measures successful. Pack and Saggi (2006) provide a survey of industry policy, which outlines many of these difficulties using case studies from around the world.

Finally, there are a range of benefits that may be difficult to capture in a formal economic model. For example, it is typically difficult to capture the agglomeration benefits in whole-of-economy models because the mechanisms through which they occur are not understood well. Where these difficult-to-assess benefits are considered likely, it would be best practice to provide a qualitative assessment of the benefits (and the probability of them eventuating) alongside a more formal assessment of costs.

# 4.4. Sporting and cultural events

Sporting events are short-lived, and often displace activity that would otherwise occur. This means that it is crucial to account for these opportunity costs.

One of the benefits of modelling approaches such as CGE is that they automatically handle many of the displacement costs that are associated with large sporting events (Madden 2006). However, some care needs to be taken to ensure that the model's assumptions reflect the real-world events.

Crompton et al. (2001) argue that the key issues to consider are:

- the extent to which visitor expenditures would have occurred anyway—the economic impacts of events are often determined by the additional expenditures that attendees make while in the region of interest. It is therefore important to ensure that any visitor expenditure associated with the event is truly additional, and

[16] Where welfare is proxied by real household consumption. Estimates have been inflated to 2015-16 dollars.

excludes expenditures that would have occurred in the absence of the event (this means that estimates need to account for any attendees who would have visited anyway, any attendees who brought forward a planned visit[17] to attend the event and any displaced visitors)

- whether accommodation can handle a large influx of visitors—if occupancy rates are already very high, it is unlikely that a new event will be able to attract significant numbers of new visitors over and above those that would have visited the region in the absence of the event
- the nature of employment opportunities created by the event—for short-term events (say over 4 or 5 days), it is unlikely that businesses would hire new full-time workers. Rather, existing employees are likely to be redeployed to meet the demand created by the event. Similarly, workers may choose to participate in the event at the expense of some other activity they would otherwise have undertaken.

In a similar vein, income flows to those outside the region need to be properly accounted for. These might include wages paid to workers who do not reside in the region of interest, and any external fees or subsidies paid to host the event (Madden 2006).

It is common for large sporting or cultural events to include an ‘induced tourism effect’. This effect is premised on the idea that the event induces future tourism over and above those that would have occurred without the event. These induced tourism effects need to be treated with caution, since evidence suggests that they often do not eventuate (For example, see Giesecke & Madden 2007; Maennig & Du Plessis 2007).

Several authors have found that large mega-events such as the Olympics and World Cup have been shown to generate large economic losses when examined after the event, even though similar studies conducted prior to the events suggested there would be large benefits (for example, see Baade & Matheson 2004; Flyvbjerg & Stewart 2012; Giesecke & Madden 2007).

The economic costs associated with sporting and cultural events should be understood, but need to be assessed against other, non-economic, benefits, such as the enjoyment local residents gain from hosting the event.

[17] For example, a study by Giesecke and Madden (2007) suggests that many of the visitors to Sydney during the Olympic Games brought forward their visit—this was evident in a spike in visitation during the Olympics followed by a strong decline afterwards.

# QUICK TIPS—INTERPRETING MODELLING

## TIP 1 The sniff test: if it sounds too good (or bad) to be true, it probably is

It is unusual for models to produce economic impacts that are multiples of the direct impact, or to produce large increases in employment. These generally only occur in extreme conditions (such as during recessionary conditions).

Do some simple calculations to test the validity of the results. If they do not match, ask why.

## TIP 2 Read the fine print

Often the key assumptions that explain modelling results are hidden deep in a modelling report. This means it will not be possible to understand the modelling results by reading the executive summary.

Reading the modelling detail will often expose an obvious flaw, or area of uncertainty, which is key to understanding how the results were arrived at. Most credible modelling will discuss these uncertainties and provide explanation of the results. Where this is not provided, treat the results with caution or seek out further detail.

## TIP 3 Recognise that economic modelling is a simplification

There is no single model capable of capturing all real-world complexity. Rather, the role of modelling is to highlight the key issues, and to test uncertainties.

This means that it is not unusual for different models to provide different answers to the same question. This is not necessarily a problem; rather, it reflects that there are significant uncertainties that need to be understood. Good modelling will highlight and shed light on these uncertainties; bad modelling will not.

## TIP 4 Question whether the basic assumptions are reasonable

There are some basic realities that all economic modelling needs to acknowledge, such as:

- Economic activity is constrained by limited resources, including capital stocks that take time to build; skilled labour; and the preferences of consumers and workers.
- The economy is dynamic and actors respond to incentives (such as prices and wages).
- There is no such thing as a free lunch—government expenditures must be paid for, and foreign investors expect to receive a return on their investments.

These basic realities mean that it is not possible to generate long-lasting gains simply by spending more money. It also means that the net economic impacts of government spending can be much lower than the direct expenditures.

## TIP 5 Take the time to understand what the economic indicator means

Economic modelling results often focus on jobs and growth. For most policy options, these are the wrong measures to consider, often providing a misleading picture of the benefits or costs of change. Better indicators of welfare are income measures such as per capita real gross national (or state) income.

Source: Morton & Clark 2016.

# 5. Interpreting results

## 5.1. What the different indicators mean

Whole-of-economy models, particularly CGE models, produce a myriad of results ranging from industry-level estimates or activity to headline impacts on GDP and income. In order to interpret the results from a modelling exercise, it is important to understand what the most commonly used measures of economic activity actually tell us about economic welfare and progress (Figure 4).

**Figure 4 Commonly used economic indicators and what they mean**


Real GDP is the most commonly used measure of economic activity.[18] It is a measure that describes the domestic production of goods and services.[19] It is often used to describe wider economic progress or wellbeing.

While GDP is closely correlated with other elements of progress or wellbeing, such as employment, education and health outcomes, it is not always a good indicator of wellbeing, and can provide misleading information about the true economic benefits or costs of policies, events or projects under consideration.

Consider the case of export subsidies—in the immediate term, they may increase production and GDP[20], but they will provide no direct benefit to domestic consumers. Rather, the costs of the subsidy need to be paid for by consumers, and domestic resources will need be deployed away from production for domestic consumption to production for foreign consumption—both of which reduce the welfare of domestic residents.

[18] At the industry-level, real gross value added is usually used to describe an industry's contribution to growth or GDP.
[19] Technically, GDP measures the production of *final* goods and services—that is, domestically produced goods or services purchased by consumers, government, investors and foreigners.
[20] Subsidies will only increase overall production where there is a slack labour market—even where this is the case, it is unlikely that export subsidies, on their own, would have any impact on GDP in the long run.

The limitations of a focus on GDP are particularly evident for projects that involve the attraction of foreign-owned investment. Where capital is foreign-owned, the income from profits are repatriated offshore, meaning that any increases in domestic income will be disproportionately lower than the changes in GDP.[21]

Employment is probably the next most commonly reported measure of economic benefit. There are obvious reasons for this—jobs provide income and keep people occupied (and perhaps even happy).

However, on its own, employment is a very poor measure of economic benefit. For example, we could generate considerable increases in employment (at least in the short run) from policies that detract from productivity (an extreme case would be to outlaw the use of tractors in food production) but would hardly be considered as making us better off.

In more recent times there has been a recognition that real per capita income and real consumption are better indicators of welfare than employment and GDP.[22] Welfare refers to prosperity and living standards and, for an economist, relates to the utility gained through the consumption of material goods and services.

Real per capita income[23] provides a measure of potential consumption earned from the fruits of production. It differs from real GDP in three ways:

- It is affected by a different price deflator (the bundle of goods consumed is not the same as the bundle of goods produced; changes to prices therefore can affect income and GDP differently). [24]
- It captures offshore net income flows (an important consideration where the owners of capital are foreign).
- It relates to welfare on a per capita basis (an important consideration if a policy or event results in flows of workers between states).

Real consumption is the difference between real income and savings, and, in economic impact analysis, is often used as a proxy measure for income effects.[25] Some caution needs to be exercised with this measure since consumption and incomes can move at different rates over time—for example, there is a tendency for dis-saving as the population ages and older citizens begin to eat into superannuation savings.

Other measures, such as wealth and stocks, provide a measure of the extent to which consumption today will affect the future. They are rarely considered in economic impact analysis, but there is a growing push for these types of measures to be considered.

[21] The extent to which any gains are captured by domestic residents depends on local employment (a percentage of the benefits will be captured in wages) and the extent to which foreign capital income is taxed.

[22] For example see ABS (2002). To overcome the deficiency of GDP as a measure of economic wellbeing, in 2002 the ABS introduced a national accounts measure called real net national disposable income (RNNDI), which accounts for the impacts of price movements, cross-country income flows and the consumption of fixed capital (each of which impact on the real standard of living of Australians).

[23] Per capita income deflated by the price of consumption or the consumer price index.

[24] The recent very large changes to Australia's terms of trade (the price of exports relative to imports) provide a good example. Recent falls in the terms of trade have constrained income growth even though GDP has expanded considerably.

[25] This can be appropriate where the savings rate is held fixed, effectively meaning that real consumption moves with real income.

## Box 8 Other results

Economic models, and CGE models in particular, include a wide range of economic variables, which may or may not be reported. Understanding what these results are, and what they mean, can be important for interpreting the results and their validity. Some important economic variables include:

- gross national income (GNI)—GDP plus any income earned by residents from overseas investments, minus income earned within the domestic economy by overseas residents. When presented in real terms, it is a good measure of real income. GNI is sometimes used interchangeably with gross national product (although they are not precisely the same measure)
- net national disposable income (NNDI)—adjusts GNI to account for income transfers made by domestic residents to the rest of the world. Real NNDI is the ABS's preferred measure of real income. Most modelling assumes that income transfers by domestic residents form a fixed proportion of income, and so assume NNDI and GNI move together. As such, real GNI is often reported as the appropriate income measure in economic modelling exercises
- terms of trade—describes the price of exports, relative to the price of imports in a common currency (foreign or domestic). The terms of trade are important since they are an important determinant of real domestic income—a reduction in the terms of trade means that either foreign parties have reduced the amount they pay for the goods and services we produce, or the cost of imported goods has risen
- exchange rates—related to the terms of trade. An increase in the ratio of $foreign/$Australian increases the purchasing power of the Australian dollar, and makes domestic residents better off, all other things being equal
- real consumer wage—the wages paid to workers, deflated by the consumer price index
- real producer cost of labour—the wage rate, deflated by the price of production (the GDP deflator)
- net foreign liabilities—the stock of net foreign debt and net foreign equities, with changes reflecting changes in the foreign borrowing and foreign ownership required to fund domestic activities (plus any changes to the valuation of debt and equity).

Source: ABS 2015; OECD 2011.

## 5.2. Reporting conventions

There is no single technically correct way to present results. Rather, there several ways in which results can be presented, each of which provide unique ways of contextualising results.

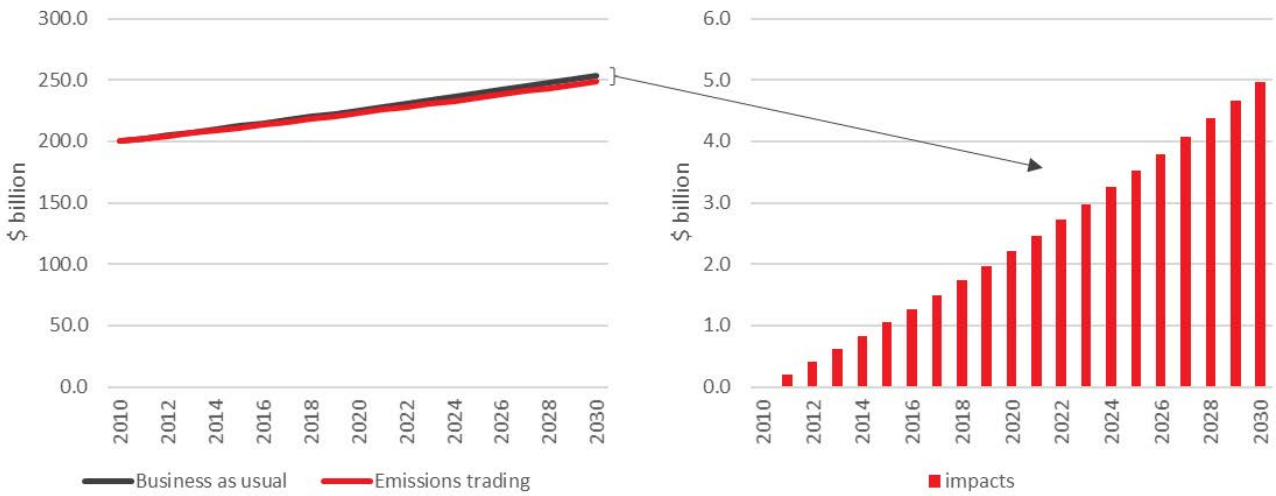
For example, consider the following statements about an (hypothetical) emissions trading scheme (ETS):

1. The ETS would slow growth by only 1/10th of 1 per cent out to 2030.
2. The ETS would mean that incomes would be around 27 per cent higher in 2031 than they are today.
3. The ETS would cause incomes to be 2 per cent lower in 2030.
4. The ETS would mean incomes would be $5 billion lower in 2030.
5. The ETS would result in a loss of income of around $25.3 billion by 2030.

Each statement provides a different way of presenting the same results—each is correct, but they have different connotations and may have different meaning to different readers.[26]

To understand how these, seemingly disparate, results are the same, it is important to understand that modelling results are constructed as impacts relative to 'business as usual'. This is illustrated in Figure 5, which presents the results from our hypothetical scenario in two separate ways. In the first chart, income growth is presented with and without an ETS. The economic impacts are the differences between the red and black lines. The second chart, presents these differences as economic impacts—that is, the economic impacts relative to business as usual.

**Figure 5 Different ways of presenting the same results**




Presented in this way, it is clear how each of the results presented above are indeed the same. The first two statements discuss the differences in the growth rates with and without emissions trading (the red and black lines above). The third and fourth statements discuss differences at 2030 (the 2030 line in the bar chart), while the last statement presents the net present value[27] of each year's impacts summed together.

[26] The results presented here are hypothetical, but loosely based on the Australian Government's (2011) modelling of emissions trading.
[27] The net present value is the sum of each year's impact, discounted to reflect the time value of money. The time value of money is normally the risk-free market interest rate, with an adjustment for risk depending on the project or investment in question.

There is no single best way of presenting results. Rather, the purpose of modelling reports should be to aid clarity. Results may need to be presented in several diverse ways to add clarity and help audiences to better understand or contextualise the modelling results.

Having said that, in some cases it would make sense to ensure results are presented in specific ways, for example:

- Where there are up-front investments of public monies, provided as subsidies to stimulate economic growth, it would normally be necessary for results to be presented in net present value terms to ensure that any economic benefits can be properly compared to the costs.
- Where impacts accrue over long time frames it would not be sensible to present results for a single year—rather, the accumulation of benefits and costs need to be presented either as net present values or as a series of yearly results.
- To allow comparison between years, results should be presented in real terms (common year dollars) rather than in nominal terms.
- When presenting results for employment, some clarity should be provided for how long jobs are expected to last—for example, jobs that last for five years have a larger impact than temporary ones.

Regardless of how results are presented, they should be presented in a way that aids interpretation, not hinders it.

## 5.3. Explaining results

A key part of any modelling exercise is to provide an explanation of results in a way that can be understood by non-experts. A full and thorough explanation of results can help to legitimise modelling results and ensure that decision-makers and affected parties are able to accept the findings of (often expensive) modelling exercises.

> *Computable General Equilibrium (CGE) modelling is a challenging field. It requires mastery of economic theory, meticulous presentation of data and familiarity with underlying accounting conventions, knowledge of econometric methods, and an understanding of solution algorithms and associated software for solving large equation systems. However, the most important requirement is the ability to communicate. CGE modelling is primarily about shedding light on real-world issues. For CGE analyses to be influential, modellers must explain their results in a way that is comprehensible and convincing to their fellow economists, and eventually to policy makers. (Dixon & Jorgenson 2013)*

While many economic issues are complex, modelling should be explained such that an informed adult who is prepared to take the time to read and work through results can understand them. Further, a modeller's capacity to clearly explain results should provide confidence that the modeller understands their own results. As Einstein famously said: 'If you can't explain it to a six year old, you clearly don't understand it yourself.'

Three key methods are used to help explain results:

- decomposing results into their key components
- the use of simplified back of the envelope (BOTE) models
- the use of sensitivity testing (Dixon et al. 2013).

**Decomposing results**

The results from whole-of-economy modelling are rarely determined by a single factor alone. This can make it challenging to understand how results were arrived at, undermine the legitimacy of well-constructed modelling, and help to obfuscate results from modelling that may be poorly constructed.

One way the problem can be overcome is by describing the results in terms of each their key components. This shows then how each of the key factors contribute to the results.

Decomposing results into their contributing factors can be important for stakeholders who may be focused on a specific area of interest. For example, a trade unionist may be especially concerned about how the direct effect of a move towards automation will affect unemployment and welfare. By decomposing the results into direct and indirect effects, stakeholder concerns can be made explicit, and compared against any offsetting indirect effects.

A decomposition of results can also be important for simplifying and explaining how key results are arrived at. For example, a study undertaken by the Centre of Policy Studies uses a decomposition to explain the factors behind recent changes in wage rates for high and low skilled occupations (Box 9).

**BOTE models**

A BOTE model is a simplified version of the larger economic model, and is often used to demonstrate the key features of the model:

> *A well designed BOTE model has two properties: it reveals the roles of major behavioural institutional and data assumptions in causing the model to generate a particular result; and it is small enough to be managed with pencil and paper (on the back an envelope) and to be presented in a limited timeframe to policy advisors. (Dixon & Rimmer 2013)*

The BOTE model generally varies somewhat between modelling projects, depending on the way that the economic shocks translate through the economy. It is generally used to create a rough estimate of the impacts using easy-to-understand metrics. These can be compared to the full model results, with explanations provided for the key differences.

More complex BOTE models can still be difficult for the non-economist to understand, and so may not facilitate general understanding. However, where a modelling exercise needs to stand up to outside scrutiny, the use of more detailed BOTE models is extremely useful.

**Sensitivity testing**

Sensitivity testing is generally good practice for large economic models. There are many unknown or disputed parameters, and it is important for stakeholders to understand how sensitive the model results are to these parameters.

Sensitivity testing involves identifying key parameters in the model, and changing their value to see how this changes results. The extent to which they are varied should reflect the extent to which there is uncertainty about the true value of the parameters being tested.

Choosing the correct parameters to vary can be difficult, but the parameters should reflect those that key stakeholders are likely to see as important (building credibility) and those that are most likely to influence the results (testing robustness).

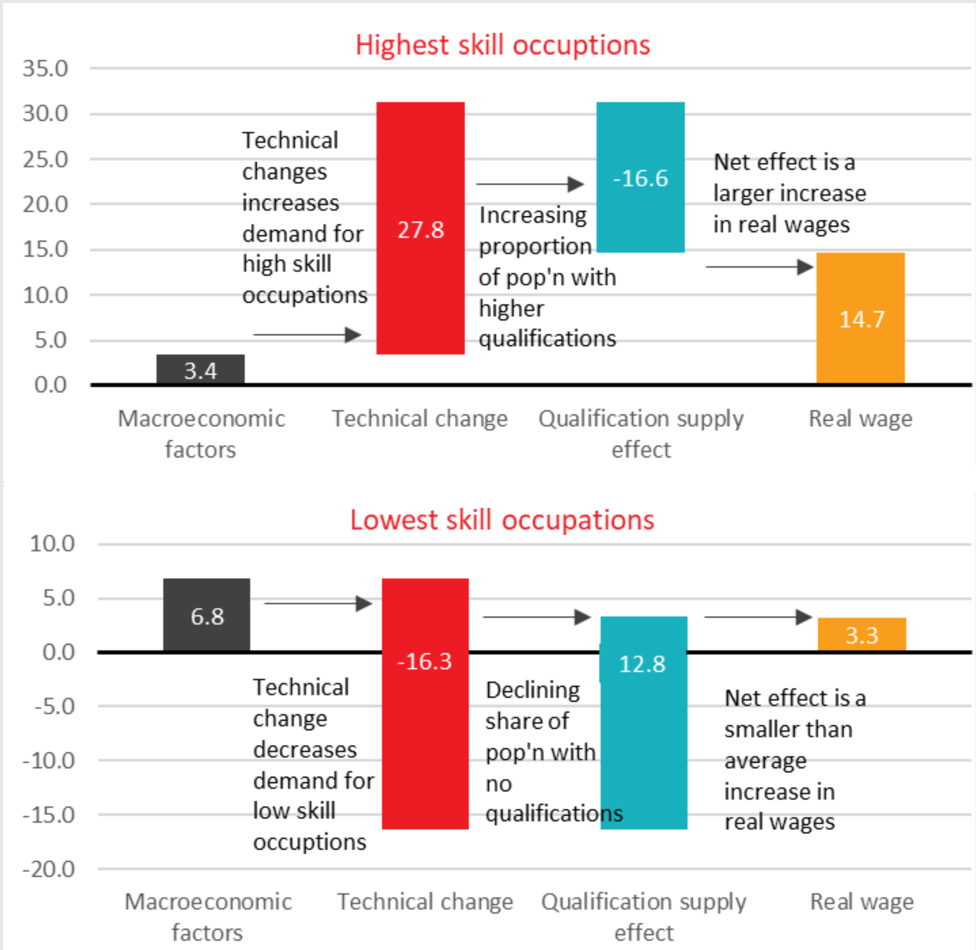
## Box 9 Decomposing results—an example

Modelling by the Centre of Policy Studies (Dixon & Tran 2017) explains changes in wage growth differentials over the period 2010 to 2017. In particular, it shows how changes in macroeconomic conditions, technical and regulatory changes and increases in the supply of skilled workers have contributed to differences in wage growth for high and low-skilled occupations.

The analysis takes a complex modelling exercise using a CGE model and a microsimulation model, and presents results in an uncomplicated way that aids understanding (Figure 6).

The analysis shows that general macroeconomic effects had a minor impact on relative wages over the period. Technical changes, such as automation of low skilled jobs and increasing demand for higher skills across a range of industries (such as nursing and child care) had a much larger impact on wage differentials. The analysis also shows how growth in the supply of highly-qualified workers has worked to dampen the wage disparities between high and low skilled workers.

**Figure 6 Decomposition of changes to occupational level wage rates**



# 6. Conclusion

Governments are the main audience for economic modelling, largely because of their role in making investments on behalf of taxpayers. As such, the public service plays a key role in influencing the behaviour of economic modellers and consequently the quality of information modellers provide to aid public discourse and decision-making.

Bad modelling has the potential to mislead decision-making, and, in turn, impose large costs on government budgets, productivity and public welfare. Bad modelling also affects the integrity of *all* modelling reducing its credibility and use as a tool for informing decision-makers on important issues.

It is therefore critical that governments have some internal capacity to understand and influence economic modelling.

Users and commissioners of modelling need to understand its limitations but be aware of its usefulness for promoting public discourse. The reality is that models are rarely, if ever, capable of capturing the full complexity of the real world. The challenge is to understand the key issues to ensure that the approximation is as good as it can be and does not mislead.

> *[A]ll models are approximations. Essentially all models are wrong, but some are useful. However, the approximate nature of the model must always be borne in mind. (Box & Draper 1987, p. 424)*

Those commissioning modelling need to be more confident in the abilities of economists and to ensure they provide the right incentives for consultants to engage in good modelling practice.

A good start would be to be less wary of adverse results from economic modelling.

An analysis using whole-of-economy models may demonstrate that a project or event will result in little economic gain, or even show that there will be a net economic loss. Does this automatically mean that the program or event should be cut or dropped? No.

We have all had a party, or invited friends over for dinner. We do not expect to make a fiscal gain or benefit from hosting these events. However, we do want to know how much they cost. That way we can make an informed decision about whether the likely enjoyment we get from hosting the event will justify the cost.

Economic modelling should not be any different. It is important for policymakers to have a good understanding of the true costs and benefits of their policies, projects and events, just as it is important for constituents to have confidence that their elected officials have access to the best information possible.

Whole-of-economy modelling exercises can facilitate this confidence. It can be complex, but the framework is normally built around some standard ideas about how the economy works. Users and commissioners of modelling should expect (and encourage) economists to take an objective view when doing modelling, and explain the results from their complex models in a way that everyday people can understand.

# References

ABS (Australian Bureau of Statistics) 2002, *Australian Economic Indicators*, *cat. no. 1350.0*.

——2015, *Australian System of National Accounts: Concepts, Sources and Methods*, cat. no. 5216.0.

——2016, *Australian National Accounts: Input–Output Tables, 2013–14, cat. no. 5209.0.55.001*.

Adams, PD, Dixon, JM & Horridge, MJ 2015, *The Victorian University Regional Model (VURM): Technical Documentation, Version 1.0*, Centre of Policy Studies, Victorian University.

Australian Treasury 2011, *Strong Growth, Low Pollution: Modelling a Carbon Price*, Australian Government, Canberra.

Baade, RA & Matheson, VA 2004, 'The Quest for the Cup: Assessing the Economic Impact of the World Cup', *Regional Studies*, vol. 38, no. 4, pp. 343–354.

Ballantyne, A, De Voss, D & Jacobs, D 2014, 'Unemployment and Spare Capacity in the Labour Market', Reserve Bank of Australia *Bulletin*, September quarter, pp. 7–20.

Banks, G 2002, 'Inter-State bidding wars: calling a truce', speech to the Committee for Economic Development of Australia, Brisbane, 6 November.

Box, GEP & Draper, NR 1987, *Empirical Model-building and Response Surfaces*, series in probability and mathematical statistics, eBook, Wiley, New York.

Crompton, J, Lee, S & Shuster, TJ 2001, 'A Guide to Undertaking Economic Impact Studies: The Springfest Example', *Journal of Travel Research*, vol. 40, no. 1, pp. 79–87.

Denniss, R 2012, *The use and abuse of economic modelling in Australia: users' guide to tricks of the trade*, technical brief no. 12, The Australia Institute.

Dixon, JM & Nassios, J 2016, *Modelling the Impacts of a Cut to Company Tax in Australia*, working paper no. G-260, Centre of Policy Studies, Victoria University.

Dixon, P 2009, 'Comments on the Productivity Commission's Modelling of the Economy-Wide Effects of Future Automotive Assistance', *Economic Papers,* The Economic Society of Australia, vol. 28, no. 1, pp. 11–18.

Dixon, PB & Jorgenson, DW 2013, *Handbook of Computable General Equilibrium Modelling*, vol. 1A, Handbooks in Economics, North-Holland, Amsterdam.

Dixon, PB, Koopman, RB & Rimmer, MT 2013, 'The Monash Style of Computable General Equilibirum Modelling: a framework for practical policy analysis', in PB Dixon & DW Jorgenson (eds), *Handbook of Computable General Equilibrium Modelling*, vol. 1A, , North-Holland, pp. 23–103.

Dixon, PB & Rimmer, MT 2013, 'Validation in Computable General Equilibrium Modelling', in PB Dixon & DW Jorgenson (eds), *Handbook of Computable General Equilibrium Modelling*, vol. 1A, North-Holland, pp. 1271–1330.

Flyvbjerg, B & Stewart, A 2012, *Olympic Proportions: Cost and Cost Overrun at the Olympics 1960–2012*, Saïd Business School working papers, University of Oxford, Oxford.

Forsyth, P 2014, *Using CBA and CGE in Investment and Policy Evaluation: A Synthesis*, staff working paper, Department of Economics, Monash University.

Giesecke, JA, Dixon, PB & Rimmer, MT 2008, ‘Regional Macroeconomic Outcomes Under Alternative Arrangements for the Financing of Urban Infrastructure’, *Papers in Regional Science*, vol. 87, no. 1, pp. 3–31.

Giesecke, JA & Madden, JR 2007, *The Sydney Olympics, Seven Years On: An Ex-Post Dynamic CGE Assessment*, general paper no. G-168, Centre of Policy Studies, Monash University.

—— 2009, *Modelling Major Projects: What are the Factors that Determine Net Social Benefits?*, Centre of Policy Studies, general paper no. G-185, Centre of Policy Studies, Monash University.

Gretton, P 2013, *On input–output tables: uses and abuses*, Productivity Commission, staff research note.

Henckel, T & McKibbon, WJ 2010, *The Economics of Infrastructure in a Globalized World: Issues, Lessons and Future Challenges*, The Brookings Institute.

Henry, K 2007, ‘Treasury’s effectiveness in the current environment’, address to staff at the Hyatt, Canberra, 14 March.

Horridge, M 2014, *ORANI-G: A Generic Single-Country Computable General Equilibrium Model*, Centre of Policy Studies and Impact Project, Victoria University, Australia.

IMF (International Monetary Fund) 2015, *Australia: Selected Issues*, IMF Asia and Pacific Department, country report no. 15/275.

Kouparitsas, M, Prihardini, D & Beames, A 2016, *Analysis of the Long Term Effects of a Company Tax Cut*, working paper, The Treasury, Australian Government.

Kudrna, G & Woodland, A 2010, *Simulating Policy Change Using a Dynamic Overlapping Generations Model of the Australian Economy*, University of New South Wales.

Madden, J 2006, ‘Economic and fiscal impacts of mega sporting events: a general equilibrium assessment’, *Public Finance and Management*, vol. 6, no. 3, pp. 346–394.

Maennig, W & Du Plessis, S 2007, ‘World Cup 2010: South African economic perspectives and policy challenges informed by the experience of Germany 2006’, *Contemporary Economic Policy*, vol. 25, no. 4, pp. 578–590.

McKibbon, WJ & Wilcoxen, PJ 1999, The Theoretical and Empirical Structure of the G-Cubed Model, *Economic Modelling*, vol. 16, no. 1, pp. 123–148.

Minifie, J & Chisholm, C 2017, ‘Myth busting claims on the impact of the company tax cut’, Grattan Institute, published at *The Conversation*, 29 March 2017, viewed 15 January 2018, <https://grattan.edu.au/news/myth-busting-claims-on-the-impact-of-the-company-tax-cut/>.

Mitchell, H 2017, ‘Forget economic modelling, real world experience wins hands down’, *The Sydney Morning Herald*, 26 October, viewed 15 January 2018, <http://www.smh.com.au/business/forget-modelling-have-a-chat-with-a-cabbie-20171026-gz8o2d.html>.

Morton, E & Clark, M 2016, *Some simple ways to better understand economic modelling*, Synergies Economic Consulting.

OECD 2011, *National Accounts at a Glance 2011*, OECD Publishing.

Pack, H & Saggi, K 2006, *The Case for Industrial Policy: a critical survey*, policy research working paper no. 3839, World Bank.

QCA, (Queensland Competition Authority) 2015, *Industry Assistance,* final report.

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Queensland Productivity Commission