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The limits of CGE modelling

The surprising assumptions behind computable general equilibrium models and the implications of not knowing about them

Economic modelling is a central element of economic and policy debate in Australia. Yet the assumptions that underpin the most commonly used macroeconomic models are rarely discussed even though they fundamentally influence model results. Too often, models are used as a tool of persuasion rather than providing objective policy advice.

Discussion paper

Richard Denniss
Matt Saunders

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Level 1, Endeavour House,
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ACT 2601
Tel: (02) 6130 0530
Email: mail@australiainstitute.org.au
Website: www.australiainstitute.org.au

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Summary

Economic modelling has become a central element of economic and policy debate in Australia. It plays a key role in debates and decisions about everything from the design of tax and welfare policies to the approval of new mines and the public funding of sporting stadiums.

This paper focuses on computable general equilibrium (CGE) modelling, the predominant type of economic model used in Australian policy debate. While aimed at the general reader, this paper takes a relatively deep dive into the inner workings of CGE models, explaining a range of assumptions, theories, and practices that can undermine the usefulness of these models in answering real world policy questions. Importantly, these features, known by few and rarely discussed, fundamentally determine the model results and the subsequent policy advice.

CGE models estimate the impact of a project or policy change on all other parts of the economy. They are referred to as general equilibrium models as they seek to analyse the entire economy, while models that focus on just one market are often known as partial equilibrium models.

The ability of CGE models to model the entire economy makes them a *jack-of-all-trades* tool of analysis. The apparent versatility of CGE models explains their popularity for use in answering a wide range of policy questions, and their profitability for the private consultancies that perform CGE modelling. Unfortunately, CGE models' underlying theoretical and data limitations can render them inappropriate, or even useless, for some policy analysis. This is particularly problematic because while CGE models are extensively used in Australia, few economists are trained in their use, or in interpretation of their outputs. Informed critique of CGE results is as rare as self-interested abuse of the models is common.

The popularity of CGE modelling in Australia grew as key models and staff were transferred from academia to the public service, and modelling became focused on supporting the policy goals of the government of the day. Discussion of the theoretical and data limitations of the models for such purposes declined as the use of the models increased. Put simply, CGE research in Australia became a tool of government persuasion rather than a tool of academic inquiry. Subsequently, with the outsourcing of government work, the CGE models found a profitable new home in private consultancies in both supporting and criticising government policy, and the lobbying of governments for the approval and financial support of large investment projects.

Part of the persuasive power of CGE models comes from the perception that they contain a large amount of objective mathematics and theory. While CGE models contain many equations, this is not same thing as a large amount of objectivity. The CGE modeller needs to make decisions about the values of thousands, potentially millions, of model variables. It is not the model that estimates the many inputs for which no good data is available, it is the modeller and the modeller's client, that make such choices.

The importance of the assumptions selected by modellers is demonstrated in the modelling for the Henry Tax Review. Many CGE models assume that that there is no long-run link between after-tax real wages and the amount of labour supplied in the economy. However, the Henry Review's modellers used a different assumption – that the long-run labour supply is positively, albeit slightly, correlated with after-tax wages. This assumption meant that the model would inevitably conclude that any reduction in income tax rates would lift after-tax wages and employment. The Henry Tax Review subsequently recommended cutting taxes on this basis. However, it was the choice of an unorthodox assumption drove this primary conclusion. The final report of the Henry Tax Review includes no discussion of the fundamental role that a single assumption about the behaviour of labour supply played in determining their "conclusion" that personal income tax cuts would benefit the economy.

It is impossible for any reader of the Henry Tax Review to know that an unconventional assumption, was relied upon by the modellers and, in turn, that this assumption is the only reason any of the proposed income tax changes were "shown" to have any impacts on long-run levels of employment or unemployment.

This report highlights and explains several little-known assumptions and theoretical design choices in CGE models that have major implications for the modelling results.

- There is no money in a CGE model, and no interest rates, credit, loans or savings as commonly understood. While the goods and services in a CGE model are expressed in dollar terms, the models themselves typically have no variables for money supply or any "price of money". No money is ever exchanged in the model. Instead, households, business and government simply swap/barter goods and services and resources amongst each other. This assumes away the role of financial assets and the entire financial system. There is no asset price inflation, ignoring the effects of house prices and stock markets. This also makes it difficult to model policy measures such as capital gains tax, wealth taxes, stamp duty, inheritance tax, or changes to superannuation and insurance.
- Relatedly, CGE models assume that inflation has no impact on the real economy, raising the question of why Governments and the Reserve Bank are so concerned about inflation, and so determined to lower it into an arbitrary range.
- Most CGE models assume that profits in each industry are zero, because perfect competition brings new entrants to any profitable industry. Yet CGE modellers

typically make little effort to remove the super-normal profits from the real-world databases that underpin the models. Attempting to model a policy such as a tax on Big Four bank profits would inevitably see the model suggest that the banking system would shrink, with banking infrastructure moving to other industries. This ignores the fact that much of the profit of Big Four banks comes from their too-big-to-fail status and related regulatory support.

- Capital goods can be used, and re-used, for any purpose at any time. Prominent CGE models include only two kinds of physical capital – structures and everything else, where "everything else" includes shovels, tractors, grain silos, blast furnaces, LNG export terminals, computers, power stations, intellectual property, and roads. Within the model it is not just possible, but costless, to convert an LNG export terminal into a solar farm. This leads to a major risk of policy makers underestimating the risk of investing in stranded assets because in a CGE model there can be no such thing as a stranded asset. Just as swords were once beaten into plough shears, CGE models assume that coal mines can be converted into hospitals, with even less effort than was required by a blacksmith to repurpose a sword. Under this assumption, supply chain risk cannot exist. This means that CGE models underestimate the costs of structural change and exaggerate the potential for policy changes to move factories, mines and other capital equipment.
- CGE results are presented relative to a business as usual (BAU) scenario of what the future "should" look like (i.e. without the policy change or new project being modelled). The assumptions the modeller makes about the BAU scenario are just as important as the assumptions the modeller makes about how the policy/project will impact on the economy. Put simply, how good or bad a policy change appears depends entirely on the assumed position of the BAU scenario at the future time where the policy change has maximum effect.
- Only successful projects are modelled. Successful and profitable projects are the only kinds of projects that CGE models can mathematically evaluate. In turn, CGE models never find that a new project is bad for the economy. In a more technical sense: projects are assumed to be successful at the microeconomic level and then fed into a CGE model to estimate the macroeconomic impacts. The potential for a successful project at the microeconomic level to be unsuccessful at the macroeconomic level is practically zero. So, the model always predicts that a modelled project is good for the economy.
- CGE models are based on conflicting theories juxtaposing for example, a "classical supply side model" in the long run with a "Keynesian short run", or a labour market that at different stages assumes and does not assume that inflation is important in determining the level of employment. While some theoretical conflict is unavoidable when simultaneously attempting to model the behaviour of tens of millions of workers and businesses, what is avoidable is misleading users about the usefulness and the limitations of the model's predictions in light of these theoretical concerns.

Beyond these assumptions, and theoretical design choices, it is important to understand that CGE model results can be presented and analysed in misleading ways. For example, the modelling generates two parallel paths of the economy (one BAU and one with the policy change being modelled). The differences between those two paths can be measured in numerous ways (nominal dollars, constant dollars, percentage change, percentage of GDP) and it is easy to make small annual effects seem big (for example by adding them up over 20 years) or to make big effects seem small (by expressing them as a percentage of a large number like GDP).

While this paper may be heavy reading for many non-modellers, its key points are relatively simple:

1. CGE models are complex tools requiring a diverse range of skills to build, maintain and operate.
2. Australia is a leading country in the use and development of these models.
3. These models are used as a tool of persuasion of governments by those seeking policy change, often for their own interests.
4. The models, by themselves, do not deliver policy advice or investment recommendations.
5. The model results are 100 per cent determined by the choices made by the modellers in designing and implementing the models.
6. Different choices create different model results.
7. Therefore, it is paramount that all consumers of model outputs are fully aware of these choices and the inherent limitations of the models. This is difficult because the models are so complex.

Applied CGE models are an impressive feat of research that are able to deliver numerical estimates to complex policy questions, based on complex economic theory, using large, complex and messy real-world databases. When all users are aware of the limitations and assumptions involved, useful policy debates can happen on the basis of their results. The models are powerful policy tools, and they can be useful in modern policy debates, they should just never be used to deceive non-practitioners in those same policy debates.

Introduction

> "When I began the study of economics some forty-one years ago, I was struck by the incongruity between the models that I was taught and the world that I had seen growing up."
>
> Nobel-Prize-Winning Economist Joseph Stiglitz.[1]

Economic modelling has become a central element of economic and policy debate in Australia. It plays a key role in debates and decisions about everything from the design of tax and welfare policies to the approval of new mines and the public funding of sporting stadiums.

Economic modelling has not always been ubiquitous in Australia and it does not play such a large role in most countries. While economic modelling may be widespread in Australia, few people know what modelling is, how it is performed, when it is useful, and when it is dangerous, even among the policymakers who spend so much money commissioning it.

This paper focuses primarily on the use, and abuse, of the most common form of economy-wide modelling used in Australia, Computable General Equilibrium (CGE) modelling. In the words of Queensland Treasury:

> 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.[2]

The paper builds on an earlier paper published by The Australia Institute that highlighted the use and abuse of input-output or "multiplier" models.[3] We are proud to report that input-output models are now less widely used than when we published that paper, and the limitations of them are better understood. To some extent, however, the decline of input-output models has simply led to increased use of more sophisticated, and expensive, CGE models.

[1] Stiglitz (2001) *Information and the Change in the Paradigm in Economics*, Prize Lecture, December 8, 2001, Columbia University, http://www.nobelprize.org/nobel_prizes/economics/laureates/2001/stiglitz-lecture.pdf

[2] Clark (2018) *Whole-of-economy Modelling: Beyond the Black Box – Queensland Productivity Commission Staff Research Paper,* https://s3.treasury.qld.gov.au/files/Research-Whole-of-economy-modelling.pdf

[3] Denniss (2012) *The Use and Abuse of Economic Modelling in Australia – Users' guide to tricks of the trade*, https://australiainstitute.org.au/report/the-use-and-abuse-of-economic-modelling-in-australia/

This new paper highlights the implications of some of the major structural assumptions on which CGE models are based, as well as the difficulties of finding and feeding accurate data into these models.

While the adage about all forms of modelling, "garbage in garbage out", is widely known, the consequences of relying on the best guesses of economic modellers for key economic variables ranging from the sensitivity of labour supply to wage growth to the ability of companies to substitute machines for workers, does not seem to be widely appreciated by those politicians, policymakers and journalists who rely heavily on modelling results. For example, commentators have pointed to CGE modelling results as proof that tax cuts lead to more employment.[4] In fact, CGE models can include an assumption that lower taxes lead to increased employment, and such models can only produce that result. If the commentators are aware of such assumptions within the model, they have chosen to remain strategically silent.

To be clear, when the results of a model simply restate the assumptions on which the model is based, then the result is proof of nothing. It is simply tautological for a model that assumes labour supply is highly sensitive to changes in after-tax wage rates to show that labour supply is highly sensitive to changes in wage or tax rates. Indeed, it would be impossible for a model based on a particular assumption to prove anything other than the assumptions that have been built into it. In turn, it is literally meaningless for a model that assumes labour supply is highly sensitive to changes in tax rates to be used as evidence that reductions in taxes will lead to a big increase in employment.

The intention of this paper is not to explain all the details of how CGE models work. Readers looking for such explanations could start with an excellent overview published by the Queensland Productivity Commission (QPC) before tackling textbooks such as Dixon and Jorgenson and taking a deep dive into CGE modelling knowledge base at Centre of Policy Studies website at copsmodels.com.[5] [6] [7]

However, it is not necessary to be an expert in CGE modelling to be an informed user of such modelling.

This paper first briefly looks at what CGE models are, considers why they are so popular in Australia and why they are used so extensively in a range of policy debates. Next, the

[4] See example of Henry Tax Review below.

[5] Clark (2018) "*Whole-of-economy modelling" beyond the black box – Staff Research Paper*, https://s3.treasury.qld.gov.au/files/Research-Whole-of-economy-modelling.pdf

[6] Dixon & Jorgenson (2013) *Handbook of Computable General Equilibrium Modelling* (Volume 1A) North Holland publishing

[7] Centre of Policy Studies (2024), *The Centre of Policy Studies Knowledgebase*, *https://www.copsmodels.com/*

importance of the model assumptions is discussed to highlight the key role that assumptions play in forming and even determining policy advice.

Having outlined the broad structure of CGE modelling, the paper then considers in detail the significance of nine little known, but highly significant, features of CGE models, their use, and the way results are often presented. This section highlights just how much of a CGE model's results, or its policy advice, hinge on a range of subjective and highly significant decisions made before and after the model is actually run. The final section draws these broad issues together into a discussion of the consequences that choices of assumptions and decisions made the by modellers has on policy advice.

What are CGE models?

Computable general equilibrium (CGE) models are an attempt to build a mathematical understanding of the behaviour and interaction of key parts of an economy. They are referred to as "general equilibrium" models as they seek to analyse the operation of the entire economy, while models that focus on just one market are often known as "partial equilibrium" models.[8]

For example, a model of the construction industry could provide researchers with insight into the impact of a major new mining project on the demand for construction workers, and their wages. A CGE model on the other hand, allows users to analyse the interaction between the construction industry and all other industries, as well as analyse the impacts of higher wages in one sector on wages, consumer spending, tax paid and the demand for imports in other sectors of the economy.

A defining feature of CGE models, compared to the closely related input-output models[9] (which also model economy-wide impacts) is that while input-output models assume unlimited resources and no price impacts, CGE models assume that labour, capital and all other resources are constrained so that growth in one part of the economy will cause contractions in other parts of the economy, via price changes that reallocate resources.

More formally, CGE models are a set of mathematical equations applied to a database of historic economic statistics and best guesses that try to capture the strength of the myriad interactions between the various components of the measurable economy.

The underlying database at the heart of a CGE model is an input-output table, which is the same starting point of input-output models.

An input-output table is like a map of an economy that describes the flows and linkages of goods and services, factors of production, and financial transactions between all industries, households, governments, and foreign trade flows with the rest of the world. For example, an input-output table provides data on the dollar value of iron-ore, transport services, diesel, labour, rent, and accounting services used to produce Australia's annual steel production. While it may seem difficult to believe that such data is available, the obligation on every firm to share their Australian Business Number (ABN) when buying any service and to regularly lodge a Business Activity Statement (BAS) to the Australian Tax Office makes the

[8] For example, in modelling the transition to a renewable energy electricity network a relevant government department could use an electricity market model focused just on the electricity market and producers results just for the electricity market.

[9] Investopedia (2024) *Input-Output Analysis: Definition, Main Features, and Types*, https://www.investopedia.com/terms/i/input-output-analysis.asp

task significantly easier for a national statistical agency such as the Australian Bureau of Statistics (ABS).

The process of converting input-output tables into a CGE model involves writing many equations, which use many assumptions, to describe the structural and behavioural relationships between workers, firms, governments, and global trade across the economy. These equations, and the assumptions about the strength of the relationships between different parts of the economy, determine the behaviour of the model. These equations and the assumptions they contain typically rely heavily on conventional, perfectly competitive, neo-classical economic theory at the firm level, with perfectly rational decision-making by households and governments, combined with an overarching Keynesian macroeconomic accounting framework.[10]

The input-output database, together with the equations and assumptions, all work together to simulate the structural and behavioural relationships between workers, firms, governments and global trade in order to help predict the impact of policy change or major new investment on future economic activity across the entire economy.

The ability of CGE models to model the entire economy makes them a jack-of-all-trades tool of analysis, albeit with a relative low degree of detail, and perhaps accuracy, for particular industries. The apparent *versatility* of CGE models is a reason for their popularity, and profitability, for use in answering a wide range of policy questions, including questions for which their underlying theoretical and data limitations render them inappropriate and often quite useless. For example, as discussed in later sections, CGE models typically do not include money or finance, which makes them unfit to modelling policies that effect financial markets.

That said, the ability of CGE models to provide forecasts for GDP, employment and other macroeconomic indicators, decades into the future, with decimal-place precision (if not accuracy), makes them highly attractive to those who can afford the hundreds of thousands of dollars (often millions of dollars) required to commission such a study. Under such circumstances, their complex nature, significant development time and wide-ranging discretion regarding how best to specify key assumptions means that there is a small, but loyal user base for CGE modelling in Australia. It is important to note that few economists are trained in the use or interpretation of CGE models. In turn, while CGE models may be extensively used in Australia, the cohort of economists, software engineers, and mathematicians who fully understand them is small.

[10] Downes (1995) *An Introduction to the TRYM model – Applications and Limitations, p.20, https://www.sciencedirect.com/science/article/pii/S1474667017470881*

Importance of CGE in the Australian policy debate

According to one of the world's most renowned researchers in CGE modelling, Professor Peter Dixon:

> CGE modelling has been prominent in the Australian economic debate since the 1970s. It helped politicians and the public to understand the likely effects of changes in trade policies and policies in many other areas.[11]

More broadly, researchers at the World Bank highlight the widespread use of CGE around the globe:

> Initially confined to universities and research institutions, CGE models today are routinely used by governments in policy formulation and debate. Modelling capacity, either in government agencies or policy research institutes, can be found in at least 20 countries around the world.[12]

The Australian Public Service has been a strong advocate for, and user of, CGE modelling. The *Australia's Future Tax System Review* from 2010, commonly known as the Henry Tax Review, relied heavily on CGE modelling to build a public case for Treasury's preferred taxes, such as land tax, and against the reliance on other taxes such as personal income taxes. In the words of the review:

> An understanding of the impact of taxes and transfers on the allocation of resources in the economy is crucial to tax policy design. A general equilibrium economic model of the Australian economy is the only viable means of assessing the economic effects of reform of the scale outlined in this report.[13]

While a wide range of state and federal government agencies have used CGE modelling, few have used it as frequently, and with such determination as the (former) Australian Bureau of Agriculture and Resource Economics (ABARE) and the Productivity Commission (PC). ABARE, particularly under its former head Brian Fischer, were world leaders in the use of CGE

[11] Dixon (2006) *Evidence-based Trade Policy Decision Making in Australia and the Development of Computable Equilibrium Modelling*, p.1, https://vuir.vu.edu.au/38945/1/g-163.pdf

[12] Devarajan (2002) *The Impact of Computable General Equilibrium Models on Policy*, p.1, https://www.pep-net.org/sites/pep-net.org/files/typo3doc/pdf/DevarajanRobinson.pdf

[13] Treasury (2010) *Australia's Future Tax System Review Final Report*, *Part 1 – Overview,* p.8 https://treasury.gov.au/review/the-australias-future-tax-system-review/final-report

modelling as a tool to exaggerate the costs of reducing greenhouse gas emissions, a tool which has been widely used globally by the fossil fuel industry ever since.[14]

Similarly, the PC, especially under the reign of former Chair Gary Banks, was an enthusiastic user of CGE modelling to build the case for some reforms, particularly tariff reductions and privatisation. A search of the PC website for the term "CGE" returns over 660 different articles. Indeed, the PC was formed from the merging of the Bureau of Industry Economics and the Industry Commission.[15] The latter was at the forefront of applied CGE research throughout the 1990s, building on the original Sectoral Analysis of Liberalising Trade in the East Asian Region (SALTER) model that eventually became, the industry standard global CGE model known as Global Trade Analysis Project (GTAP) and housed at Purdue University.[16]

Under the leadership of Fischer and Banks, ABARE and the PC were not just enthusiastic about the use of CGE modelling, they were also enthusiastic about ensuring the results of such modelling exercises built a persuasive case for their preferred policy positions. As Banks notes:

> Tariff reform again provides a classic instance of evidence [CGE modelling] being used to galvanise potential beneficiaries from reform in the policy debate…For evidence to discharge these various functions, however, it needs to be the right evidence; it needs to occur at the right time and be seen by the right people. That may sound obvious, but it is actually very demanding.[17]

More generally Dixon notes the ability of CGE modelling to build a persuasive case for many policy reforms:

> By contributing to public understanding, CGE modelling has helped make it politically possible for governments to implement previously highly unpopular policies such as: cuts in protection; privatization of electricity supply, railways, and other former public utilities; and changes in labour-market regulations and regulations governing particular industries including stevedoring, sugar and coal mining.[18]

[14] Kurmelov (2024) *The Australian Public Servant Who Helped The Oil Industry Convince The World That Stopping Climate Change Was Too Expensive*, Drilled, 22 Nov 2024, https://drilled.media/news/Ipieca3

[15] PC (2003) *From Industry Assistance to Productivity: 30 Years of 'The Commission',* https://www.pc.gov.au/about/history/thirty-years

[16] Global Trade Analysis Project (2024) *About GTAP: Global Trade Analysis Project, https://www.gtap.agecon.purdue.edu/about/project.asp*

[17] Banks (2009) *Evidence-based policy-making: What is it? How do we get it?*, https://www.pc.gov.au/__data/assets/pdf_file/0003/85836/cs20090204.pdf

[18] Dixon (2006), p.1.

So, while it is relatively straightforward to establish the widespread use of CGE modelling in Australia, and to a lesser extent the rest of the world, the question of how they became so popular is rarely discussed.

Dixon explains CGE's popularity in the 1980s and 1990s in Australia as a result of three key factors: Australia had the right issue (tariff protection), the right institutions (Tariff Board, Industry Commission, PC), and the right model (ORANI) to do CGE well.[19] But despite mentioning another point, Professor Dixon perhaps misses the most important reason.

Dixon writes that early on, after initial failures, key model research and staff were transferred from academia to the public service, and this sharpened the focus on practical policy work.[20] Within academia, research had tended to focus on the theoretical and data limitations of the use of such models for highly specific, and highly political, policy debates. Shifting to the public service, the research inevitably leans towards supporting the policy goals of the government of the day. Perhaps here lies the reason for its popularity in Australia.

In other words, once moved into the public service, the research and model development likely focused far more heavily on answering specific government questions rather than focusing on asking broader questions such as "is this model well suited to this policy question?" or "are the results of this model being reported as objectively, or as persuasively, as possible?".

Similarly, to answer the kind of policy questions that governments ask, economic models and modellers need to speak the language of government. In a period of rapid economic reform throughout 1980s and 1990s the models were developed in order to produce outputs in the same language politicians were using to sell the policies being modelled to the public. In this manner, the models became good at developing seemingly precise results for GDP, current accounts deficits, budget deficits, exchange rates, unemployment, export volumes, and household disposable income, rather than the more academic and jargony sounding, marginal utility, deadweight losses and equivalent variations. As Dixon and Jorgenson explain:

> CGE modelling is primarily about shedding light on real-world policy issues. For CGE analyses to be influential, modelers must explain their results in a way that is comprehensible and convincing to their fellow economist, and eventually to policy makers.[21]

[19] Dixon (2006), p. 6-7

[20] Dixon (2006), p. 7

[21] Dixon and Jorgenson (2013) *Handbook of Computable General Equilibrium Modeling Vol 1*, https://www.sciencedirect.com/topics/social-sciences/general-equilibrium-modeling

Put simply, when key CGE research in Australia was significantly transferred to the government, the models became more of a tool of government persuasion than a tool of academic inquiry. In turn it should come as no surprise that CGE models became popular with governments, and eventually their consultants, so long as models continued to support government policy. Indeed, among CGE practitioners, one anecdotal telling of the history of the how the Australian-government-funded SALTER global CGE model found itself on the other side of the Pacific to become the more academic focused GTAP model was because SALTER was no longer producing results the government desired on trade liberalisation issues.

CGE has become so important to the political debate in Australia because successive governments, through agencies such as the Industry Commissions, PC and ABARE, made it that way. Model development, funded at least in part by the government, leaned towards addressing government policy goals and speaking the language of government.

But just as importantly, in a country also focused heavily on large-scale investment projects, CGE models that so easily spoke the language of government found a big new supporter-base in multinational corporations seeking government subsidies and assistance for their next big projects.

While the precise history of why the Australian political debate is so reliant on economic and CGE modelling is debatable, the fact they are still popular and relied upon by so many politicians to justify policy changes means that a thorough understanding of these models is needed to better judge the merits of proposed policy changes.

The next sections of the paper focus on some of the less well-known features, issues, and problems of these models, how they are constructed and implemented, and the related results presentation, to better help understand and judge CGE models' contribution to the policy debate.

Importance of assumptions

> The values of major parameters in many CGE models are little more than best guesses.[22]

It is difficult to overstate the importance of assumptions in determining CGE model results, yet they are rarely discussed in much detail. The CGE modeller must make subjective assumptions about variables ranging from the rate of depreciation of physical assets to the substitutability of locally produced motor vehicles compared to imported alternatives. As well, the modeller must make subjective decisions about how variables interact, such as:

- to what extent do income tax rates affect the decision of how many hours to work in a week;
- to what extent can a car factory be used to produce fridges; and
- to what extent is work and leisure time substitutable.

The choice of assumptions is particularly challenging for CGE modellers since their models attempt to describe all of the interactions between all of the components of the entire domestic or even global economy.

The modellers themselves are aware of the importance of these assumptions and their vital role in directly determining model results as noted by Banks:

> Any model comprises many assumptions and judgements which can significantly influence the results. For example, the Productivity Commission and industry consultants used *similar models* recently to estimate the economic impacts of reducing tariffs on cars. The Commission found that there would be significant *economy-wide gains* from maintaining scheduled tariff reductions. The other modellers, using *different (and some less conventional) assumptions,* projected *net losses*..." [emphasis added][23]

Part of the mystique, and in turn persuasive power, of CGE models comes from the perception that contained within the model is a large amount of objective mathematics and theory. While CGE models contain many equations, this is not same thing as a large amount of objectivity, or precision. Take the following example using simple high-school maths to illustrate the role of assumptions in determining model results. Consider the following equation:

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[22] Bandara (1991) *Computable General Equilibrium Models for Development Policy Analysis in LDCs*, Journal of economic surveys, vol. 5, no. 1, pp. 3-69

[23] Banks (2008) *Evidence-based Policy-making: What is it? How do we get it?* https://www.pc.gov.au/__data/assets/pdf_file/0003/85836/cs20090204.pdf

$$4x - 2 = 10$$

It is a relatively straightforward process to solve this equation to find the value of **x**. By adding 2 to each side of the equation we learn that 4x must equal 12, then dividing each side by 4 the answer for **x** is 3.

Now consider the next equation that includes an extra variable named **b.**

$$4x - 2b = 10.$$

Now it is impossible to find the value of x. The value of x depends on the value we assign to b. If we *assume* that b is equal to 1, then the value of x is still equal to 3. If on the other hand, we *assume* that the value of b is equal to 2 then the value of x becomes 1.5.

In this simple example the assumption made about the value of b directly determines the value of x. That is, by subjectively deciding on the value of the other variable (b) we simultaneously determine the value of another value (x) even though it appears as if that variable (x) was objectively determined by the mathematics of the model. The exact same process happens in CGE modelling., just on a much larger scale, with much bigger consequences.

The CGE modeller needs to make decisions about the values of thousands, potentially millions, of model variables. And all of those subjectively determined assumptions work together to directly determine the model results. That is, by design a CGE model links the behaviour of all industries and all factors of production, so again by design, if one assumption about one industry is wrong it will have consequences for all industries. But, to be clear, it is not the model that makes guesses about all of the assumptions for which no good data is available, it is the modeller, and the modeller's client, who make such choices.

An important aspect of the assumption choice problem is that once an assumption has been made about the value of a variable, the model cannot change that assumption while running, even if the assumed behaviour would likely change in response to the policy proposal that is being modelled. Another important aspect is that the assumptions, on which the modelling necessarily relies, are simply too numerous to plausibly consider or explain.

For example, it is common practice in CGE modelling to assume that industry-specific productivity is equal to economy-wide average productivity. This assumption may be adequate until policies are modelled that target specific industries. For example, if the model were used to estimate the economy-wide impacts of a new LNG facility in the WA economy, which is already at close to full employment and has a shortage of construction workers, then the massive construction effort will likely require increased productivity in the construction industry, since construction workers and resources are so scarce. Yet the

modeller has already assumed that construction industry-specific productivity cannot change.

If the modeller wanted to make the model determine this productivity impact of a new project on productivity in the gas industry, then the modeller would need to write an extra equation describing the relationship between construction-sector activity, labour shortages and construction-sector productivity. In turn, that new equation would contain additional variables that would require assumptions. In this example, the assumptions would concern an elasticity governing the rate at which the construction industry firms can make productivity gains in response to labour shortages. Good luck to the modeller finding an existing study that has empirically estimated this effect.[24]

In this example of LNG in WA, the model's lack of industry-level productivity growth would manifest in the model results as significantly higher construction costs. But, luckily for proponents of large gas projects, a common approach is to simply assume that there is a high degree of labour substitutability. Under such assumptions, café workers in Perth can easily convert into welders in Karratha. If this assumption of high labour market substitutability is chosen by the modeller then the results will show that Perth-based baristas can instantaneously become Kimberly-based mining engineers. Such an assumption about perfect labour substitutability would minimise the apparent cost pressures and crowding out of other economic activity, and artificially boost economic gains of investing in more LNG.

The key points from this simple example are that:

1. Once an assumption has been made, it cannot change, even if in reality the variable would likely change in response to policy changes.
2. New equations to overcome unrealistic assumptions just create more assumptions.
3. Combinations of assumptions can create unrealistic economic behaviour.

A practical, real-world example from recent history should help further clarify that assumptions determine results.

A PRACTICAL EXAMPLE – THE HENRY TAX REVIEW

An important practical example of the fundamental importance of the assumptions selected by modellers is the assumption about the elasticity of the long-run labour supply curve used

[24] This also an important point more generally. Often assumptions need to be made about variables that are unobservable in real world, difficult to estimate, or no existing study has attempted to measure. In such cases the modeller has to guess.

in the modelling for the *Australia's Future Tax System Review* also known as the Henry Tax Review.[25]

The elasticity of the long-run labour supply curve describes the relationship between after-tax wages and the supply of labour that is offered up by the representative household in the model.[26] It is a vitally important assumption because it determines whether many policy and tax changes will have any long-term effect on the level of economy-wide employment and in turn GDP. To be clear, for the Henry tax review, the choice of assumption about the shape of the labour supply curve was what determined whether the modelling results would show that income tax would affect long-term employment, or whether there would be no effect.

A common assumption used by CGE modellers about the long-run labour supply curve is that there is no link at all between after-tax real wages and the amount of labour supplied by the household sector.[27] That is, it is common to assume a long-run labour supply elasticity with respect to real wages of zero. By assuming that there is no long-run relationship between wages and the amount of labour supplied, the labour supply curve is said to be vertical at the rate of employment consistent with the non accelerating inflation rate of unemployment or the NAIRU.[28] This standard CGE assumption conveniently aligns CGE models with the broad economic consensus from the RBA and Treasury on the assumed behaviour of unemployment and inflation that, in the long-run, unemployment will adjust to the NAIRU (sometimes called the natural rate of unemployment*)*, and that population growth, participation rates, and a range of institutional factors determine the long-run level of employment and unemployment, not real wages.[29] [30]

But the Henry Tax Review modelling was not based on the standard CGE assumptions about the relationship between income tax and labour supply, and nor was it consistent with the Treasury and RBA's usual view about how the Australian economy works.

Rather than use conventional CGE assumptions that are consistent with the Treasury and RBA view of how the Australian economy works, the consultant modellers commissioned by the Henry Tax Review, KPMG Econtech, chose a different assumption from the common practice of assuming a vertical long-run supply curve. Their motive for doing so was

[25] The Treasury (2010) *Australia's Future Tax System Review Final Report, https://treasury.gov.au/review/the-australias-future-tax-system-review/final-report*

[26] In CGE models, a single representative household is usually assumed, and equations written, to represent the economic behavior of all households in an economy.

[27] Dixon and Rimmer (2002) *Dynamic General Equilibrium Modelling for Forecasting and Policy – A Practical Guide and Documentation of MONASH,* North Holland Publishing, p.205-210

[28] Dixon and Rimmer (2002) p.205-210

[29] RBA (2024) *Assessing Full Employment in Australia, Bulletin – April 2024,* https://www.rba.gov.au/publications/bulletin/2024/apr/assessing-full-employment-in-australia.html

[30] Treasury (2021) *Estimating the NAIRU in Australia*, https://treasury.gov.au/publication/p2021-164397

presumably based on their knowledge that there would be little point undertaking a modelling exercise into the design of the tax system if income taxes were assumed to play no significant role in determining employment and GDP (as they are in most CGE models used in Australia).

With the backing of selective evidence, the modellers of the Henry Tax Review chose a labour supply elasticity assumption that suggests long-run labour supply is positively, albeit slightly, correlated with after-tax wages. That is, the KPMG Econtech modellers commissioned by Treasury assumed that if income taxes are cut, then after-tax wages will rise and, as a result, households will supply more labour in the long run, thereby increasing economic growth and community welfare, building the case for the tax cut.

Of course, while many CGE modellers assume that the long-run supply curve is vertical (in other words, that there is no relationship between wages and labour supply in the long run) there are also many economists who disagree and significant evidence to support such alternative views. Unsurprisingly, the Henry Tax review chose to rely on such evidence, given the focus of their inquiry was to build a case for the Treasury's preferred versions of tax reform, namely income tax cuts. More surprisingly, the evidence they chose to rely on in justifying their preferred assumption is weaker than would usually be accepted for publication in an academic journal.

In order to support their decision to break from the standard CGE assumption that wages do not have a long-run impact on labour supply, and to instead assume changes in income tax rates would have a long-run effect on the amount of labour supplied, the modellers working for the Henry Tax Review relied on a number of papers, with most evidential weight from two key papers, namely:

1. Fuchs, Krueger, Poterba (1998) based on a 1997 survey of 65 labour economists' best guesses of the likely slope of the labour supply curve in the US with a range of outcomes, with a mean of 0.1 and median of zero for men, and mean of 0.45 and median of 0.3 for women.[31] [32]
2. Stacey and Downes in 1995 at Treasury on the design of the TYRM model empirically found an elasticity of 0.2.[33] [34]

[31] KPMG Econtech (2010) *CGE Analysis of the Current Australian Tax System – Final Report*, p.102 and 60, https://www.murphyeconomics.com.au/Information/tax/KPMG_Econtech_Efficiency%20of%20Taxes_Final_Report.pdf

[32] Fuchs, Krueger, Poterba (1998) *Economists Views About Parameters, Values, and Policies: Survey Results in Labour and Public Economics"* Journal of Economic Literature, vol 36, September 1998

[33] KPMG Econtech (2010), p. 102

[34] Interestingly, while Treasury publicly discusses the NAIRU, suggesting their support for the theory, a model with a positive long-run labour supply elasticity would "happily" forecast unemployment consistently below the NAIRU meaning the model is not fully compatible with the theory they preach.

Among the various estimates listed by the Henry Tax Review modellers, their final choice of assumed labour supply elasticity of 0.2, in line with Stacey and Downes, was conveniently at the high end of the range. They decided on this upper bound figure of 0.2 despite the median survey results in Fuchs, Krueger, Poterba being an elasticity of zero for male workers.

And while the Henry Tax Review modelling did contain sensitivity testing around this assumption, it was not extended to an elasticity of zero, which is the most commonly used assumption in Australian CGE studies, and within the range of values from the surveyed US economists cited by the review.[35] Moreover, later research papers on the Treasury macroeconomic model (TRYM) by Dowes have used a long-run elasticity of zero, noting that the labour supply "is deliberately drawn vertical as there is very little evidence of a long-run response to real wages".[36] Such an admission provides strong evidence of the need for the Henry Tax Review modelling to at least undertake sensitivity testing with the same elasticity often used by Treasury, the department that commissioned the review.

The consequence of choosing this assumption about labour supply elasticity for CGE modelling results is that any reduction in income tax rates will lift after-tax wages leading to an increase in labour supply and employment over the long-term. Put simply, the assumption made before the modelling even started was that cutting income taxes will increase employment in the long-run, and subsequently cutting incomes taxes was a recommendation of the Henry Tax Review. Put simply, the choice of an unorthodox assumption drove the primary conclusion of the Henry Tax Review.

The hidden power of assumptions, as opposed to the models themselves, is highlighted by the fact that the final report of the Henry Tax Review includes no discussions on the fundamental role that a single assumption about the behaviour of labour supply played in determining their conclusion that personal income tax cuts would benefit the economy.

It is impossible for any reader of the Henry Tax Review to know that an unconventional (at least within the field of CGE modelling) labour supply assumption, was relied upon by the Henry Tax Review modellers and, in turn, that this relatively unorthodox assumption is the only reason any of the proposed income tax changes were shown to have impacts on long-run levels of employment or unemployment.

There is a lack of discussion about labour market elasticity assumptions, despite the summary report highlighting the importance of other CGE modelling assumptions about producer and consumer behaviour. That discussion would have been the appropriate place to also note the fundamental importance of the labour market assumption, and the

[35] KPMG Econtech (2010), p.60

[36] Downes and Bernie (1999) *The Macroeconomics of Unemployment in the Treasury Macroeconomic (TRYM) Model*, TYRM Related Paper No. 20, https://treasury.gov.au/

somewhat unconventional choice used in the KPMG Econtech study.[37] More worryingly, Henry has at other times strongly hinted at his own belief in the vertical long-run labour supply curve, and likely an understanding of the importance of the assumption when he said:

> [W]e need to have an appreciation of the consequences of policy intervention in an economy operating at, or close to, full employment…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.[38]

A final important question then, is whether Henry was aware of the existence of, the importance of, and the lack of evidence for, one of the key assumptions made by the modellers he commissioned for the report that so often bears his name. As the issue is not discussed in his report, we will perhaps never know but, to be clear, it was the assumption not the model or Henry that drove the key conclusion of the Henry Tax Review, and it is not clear who decided to make it. That said, the example highlights the importance of paying attention to the detail and, as Henry has said elsewhere, "Analytical rigour demands soundness of empirical methods, analytical tools, models and frameworks. Analytical rigour should be the foundation upon which all [policy] advice is based".[39]

[37] Treasury (2010) *Australia's Future Tax System Review Final Report – Part 1 Overview*, p.8, https://treasury.gov.au/review/the-australias-future-tax-system-review/final-report

[38] Clark (2018), p.16-17

[39] Henry (2007) *Challenges confronting economic policy advisers*, Views from the Inside, 3. ANZSOG, https://anzsog.edu.au/app/uploads/2022/06/Views_from-the-Inside-3-Henry-2007.pdf

Little-known assumptions with large implications

Every one of the thousands of subjective assumptions made in a CGE model has an impact on the operation of the entire model and, in turn, the overall results. If labour supply is assumed to be sensitive to after-tax wage rates, then that one assumption will have a significant impact on the model's forecasts not just for employment but also for the capital/labour ratio, productivity growth, household spending, GDP, and government revenue. The whole point of a CGE model is that it is a *general* equilibrium model that, by design, creates linkages between all factors of production, industries, and sectors.

With that in mind, the following sections highlight a number of surprising, and for many counterintuitive, assumptions and features that are regularly built into CGE models. The point of discussing these assumptions and features is not to mock them, but to highlight to a broad audience how the most commonly used economic models are heavily dependent on assumptions that few people would likely consider plausible or likely.

While these assumptions were initially made in good faith by researchers looking for simple solutions to highly complex model-design problems, now that CGE models are so widely used to prove that some policies are good for the economy, it is important that they are more widely understood. As noted by Banks in regard to tariff reform, "Tariff provides a classic instance of evidence [CGE modelling] being used to galvanise potential beneficiaries from reform in the policy debate."[40]

In an environment in which non-expert users often rely heavily on the results of CGE models, it is important for a wide audience to understand the absurdity of some of these assumptions, and the significant consequences of accepting them uncritically.

Some of these issues relate not just to policy formulation by CGE models but also in the other popular area of CGE use: the examination of the economic impacts of large-scale fossil fuel investment projects that require evidence of strong economic benefits to help overcome community, scientific and political objections to continued fossil fuel expansion.

[40] Banks (2009), p. 7

THERE IS NO MONEY OR FINANCE IN A CGE MODEL

Given that the most common headline to flow from a CGE modelling report is that a new policy or big new fossil fuel project will boost GDP by billions of dollars, many people might be surprised to learn that most CGE models do not include, or even attempt to model money or the role of finance in the economy. And since there is no money there are no interest rates on money and debt, or other financial instruments.

Given the prominence that decisions made by the RBA about the price of money (interest rates) play in our economy, it is fair to say that the tradition among CGE modellers of ignoring money and interest rates reduces the usefulness of such models for policy and project evaluation.

To be specific, while the goods and services and incomes in a CGE model are expressed in dollar terms, the models themselves typically have no variables for money supply, nor any price of money, nor any transaction demand for money.[41] In a CGE model, households and businesses do not require a stock of money or other financial assets to undertake transactions in the model. That is, in a CGE model, households, business and government simply swap/barter goods and services and resources among each other. And while the value of these goods and services is denominated in dollars, no money actually exists in the model, no money is ever exchanged in the model, and in turn hoardings of money (savings), access to credit, and the price of credit play no role in the behaviour of actors in the model. That said, CGE models do have a banking industry, but, bizarrely, the core role performed by banks is assumed to be unnecessary.

Bandara summarises this assumption as follows:

> In such CGE models, it is *implicitly* assumed that the monetary authorities adjust the money supply of the economy such that it is consistent with the changes in the domestic price level emerging from policy simulations.[42] [emphasis added]

It is important to note the use of the word “implicit” in the above quotation. None of the behaviour described by Bandara is actually modelled or described by the equations in the model. The money supply and price of money do not interact with any variables in the model as they are, literally, not included in the model. The reference to an “implicit assumption” is simply the modellers providing a rationale to users of the model as to why it is safe to ignore such a variable when building a mathematical model of all the key parts of the economy. Few readers of CGE modelling reports are likely to be aware that the results

[41] The transaction demand for money is the demand for cash and bank deposits that arises from the absence of the perfect synchronization of payments and receipts in all manner of economic activity. Holding cash and other liquid assets bridges the gap between payments and receipts. Wikipedia (2024) *Transactions demand*, https://en.wikipedia.org/wiki/Transactions_demand

[42] Bandara (1991), p.30

are based on the assumption that it is safe to ignore the money supply, the availability of credit, and the price of credit.

In more technical terms, by assuming there is no money, the model is said to assume "money neutrality". This means that the model assumes that the money supply, demand for money, and the price of money, have no impacts on real variables such as real GDP or the level of employment, an assumption that some at the RBA may find unconvincing.

The consequences of assuming there is no money

The consequences of having no money or finance in CGE models goes well the beyond the simple assertion that money has no impact on the real economic variables. The belief that it is reasonable to assume that there is no money or credit in an economy is, in practice, the belief that it is reasonable to assume that the entire financial systems of modern economies have practically no effect on real economic outcomes. For example, without money or finance in a CGE model, modellers are assuming that the margin between lending and borrowing rates is irrelevant, the ability of the finance sector to price risk is irrelevant, and small businesses that are owed money by large businesses can never go bankrupt due to slow payment of debts by large companies.

The decision to exclude money from CGE models also means that households cannot save by holding a stockpile of money, and they cannot invest in financial instruments such as bank accounts, term deposits, stocks, and bonds. Since money does not exist, it cannot act as a store of wealth. Generally, households can neither save cash nor make portfolio investment decisions in a CGE model.

In CGE models typically the only way households can increase their wealth is to increase their investment in, and holdings of, real capital goods that are in turn leased back to the industries in the model. Households are assumed to either buy more capital goods or not to save at all. Buying and selling capital goods is typically assumed to be costless and instantaneous, which not only raises questions about why such a large financial services industry still exists in the input-output tables the CGE models are built from, but also why real-estate agents and business equipment suppliers and much of the retail industry are needed.[43]

[43] Some of the more sophisticated global models may include a rudimentary global bond offered by a global bank to aid the investment in capital goods in other countries, but this is simply to ensure that for each country in the model, domestic savings do not have to exactly match domestic investment in real capital equipment. But globally, it is still the case that total savings equals total investment in real capital goods. There remains no option to do financial transactions, or to make financial portfolio decisions. There exist no prices for financial assets and instruments. In a theoretical world with no way to make financial portfolio decisions there should exist no finance industry, but the underlying databases still contain a large financial sector, so what does that sector do?

Investment decisions by firms and households in these models are in turn assumed to be made in a very rudimentary manner since there are no financing and financial portfolio decisions to be made. Once the modeller has assumed that it is impossible to save money in the bank and has assumed that perfectly competitive firms have no profits to distribute in the form of dividends (see below), households have no choice but to invest in new capital equipment, no matter what their expectations, animal spirits or inter-temporal time preferences tell them.

Firms in a CGE model are assumed to be unable to make choices between investing in a production expansion, paying higher dividends or choosing between bonds and equity for acquiring additional financing. By assumption, there can be no share buybacks as there are no shares to buy or sell.

Another implication of assuming there is no money or other financial assets is that there is no asset-price inflation, so the wealth effects of rising stock markets and house prices are not captured in a CGE model. And because the model ignores them, the model implicitly assumes that such wealth effects have no impact on consumer spending, economic activity, or employment. Moreover, with no financial asset prices, there can be no financial market instability, no global financial crises, or stock market crashes, and no flow-on impacts to the real economy.

The biggest implication of this assumption is that monetary policy does not exist in a CGE model. With no money supply, no transaction demand for money, no desire to hold money as savings, and no price of money there are no conventional interest rates, and in turn no monthly adjustments of official interest rates that can be made. And in multi-country CGE models, since there is no money, there is no way to exchange foreign currencies, and no exchange rates as commonly understood.[44]

Moreover, as discussed more fully in the next section, the assumption of money neutrality also means the average level of prices, often measured by the consumer price index (CPI), also has no impact on real economic variables, so the RBA effectively has nothing to worry about, and nothing to do.

From a policy perspective more broadly, with no money, banking or other financial instruments, it is difficult to accurately model a raft of policy measures including capital gains tax, wealth taxes, stamp duty, inheritance tax, or taxes or policy changes to financial institutions of all kinds including superannuation and insurance. This makes it difficult to

[44] Some models like GTEM do include a variable to represent the real exchange rate, defined as the rate at which domestic CPI bundles can be swapped for units of the global numeraire. Pant (2007) *Global Trade and Environment Model*, Ch. 7. https://daff.ent.sirsidynix.net.au/client/en_AU/search/asset/1028039/7

measure the impacts of other taxes and policy settings that depend on banking, such as negative gearing.[45]

Finally, it is worth keeping in mind that the original reason for assuming no money in CGE models was simply because the neo-classical economic theories underpinning the models also assumed money did not exist. These theories are over 150 years old and the role and understanding of complex financial systems, to the extent they existed, was then very limited. Assuming away money was a simplification to focus on what was then considered more important: the exchange of goods, services and physical resources.

On a positive note, in response to the theoretical shortcomings, adding money and financial systems to CGE models is an area of current research.[46] But it remains the case, at least in the Australian political debate, that nearly all the modelling used to justify big policy change and justify government backing of *big-new-projects* is done with models that do not include money or finance. As noted by Anger and Barker, while there have been many attempts to include money, debt and banking into recent models since the GFC, these models continue to lack two-way feedback mechanisms from "financial to real" and "real to financial".[47] Instead, they typically continue the tradition that only "real to real" impacts matter. In effect, attempts to add finance and money to CGE models simply add passive financial tracking of the real activity rather than actively determining real economic activity.

INFLATION HAS NO IMPACTS ON THE REAL ECONOMY

In Australia, inflation is most frequently measured by the consumer price index (CPI) which is the weighted average price of a selected basket of goods and services. Both the goods included in the basket, and the weights attached to each of them, change over time. Various tweaks to the standard calculation of the CPI are used to develop a measure of inflation that the RBA uses to judge whether interest rates should go up or down. The thoughts of members of the board of the RBA are a constant topic in Australia's economic and political debates, presumably because most people believe that interest rates and inflation have significant impacts on economic outcomes for all Australians.

The previous section discussed how CGE models without money or finance do not include interest rates on financial assets. This section looks at the related issue of how, in CGE

[45] HM Revenue & Customs (2013) *HMRC's CGE Model Documentation*, https://www.gov.uk/government/publications/computable-general-equilibrium-cge-modelling, p.5

[46] Lkhanaajav (2016) CoPS Style CGE Modelling and Analysis, CoPS Working Paper No. G-264, https://vuir.vu.edu.au/38865/1/g-264.pdf, p.14

[47] Anger and Barker (2015) *The Effects of the Financial System and Financial Crises on Global Growth and the Environment,* https://link.springer.com/chapter/10.1057/9781137446138_5

models, inflation, or the nominal price level, is assumed to have no impact on the real economy.

In CGE models, inflation is measured as the weighted average price of all goods and services consumed by the representative household. In this way, inflation is defined in line with economic theory that says inflation is the continued increase in all prices, not a subset of prices tracked by the CPI. In this way, if the modeller were to model the impacts of a 10% increase in the CPI, then all prices would go up by exactly 10%. Whereas in reality a 10% increase in the CPI would inevitably involve some prices increasing by more than 10%, some less. Few, if any, would increase by exactly 10%.

While it may be no surprise that modellers apply a range of tests to their models to ensure mathematical accuracy, it is perhaps surprising that one of the common tests is to increase the CPI by 10% and to check that all prices do in fact increase by exactly 10%. This test is known as a homogeneity test.[48]

For the homogeneity test, the modeller will also check to ensure the quantity variables are all equal to zero after the 10% inflation shock is modelled. This means the modeller checks the model, by running a homogeneity test, to ensure inflation and the level of the CPI have exactly zero impact on all real economic variables, including the quantity of output, employment, exports, and imports, in each and every industry, and real GDP, real household consumption, real wages, and total employment.

The homogeneity test is important as it confirms the model is fully compliant with the assumption that inflation has no real impact on any economic agents or decisions, including that inflation leads to no distortions, changes in distribution, or any other impacts associated with the inflation that organisations like the RBA believe (in reality, not the model) are so harmful.

CGE models are structured like this primarily as a result of the economic theory underpinning the model, in particular the assumption of money neutrality, and the reliance on Walras Law.[49] In assuming the Walras Law holds, the modeller is saying that if an economy is made up of 100 markets and 99 of those markets are in equilibrium then the 100th market must also be in equilibrium.[50] The consequence of assuming Walras Law is

[48] Verikios, Hanslow, Mariano and Clements (2021) *Understanding the Australian Economy: A Computable General Equilibrium Model with Updated Data and Parameters,* Griffith University – Discussion Paper Series, *https://www.griffith.edu.au/__data/assets/pdf_file/0036/1372599/Understanding-the-Australian-economy_-a-computable-general-equilibrium-model.pdf*

[49] Faster Capital (2024) *Walras Law: Understanding the Core of Economics: Walras Law Explained*, https://fastercapital.com/content/Walras-Law--Understanding-the-Core-of-Economics--Walras-Law-Explained.html

[50] A full description of the complex Walras Law is beyond the scope of this paper, but the use of Walras Law, not to put too fine a point on it, allows CGE models to exist as applied models, rather than theoretical mind experiments.

that the model can only model 99 markets and an assumption needs to be made about the price in the 100th market. The price of the 100th market is assumed to remain fixed at 1 and all other prices move relative to that fixed-price assumption.

A common approach by CGE modellers is to assume the CPI price is fixed at 1, and that all prices are said to move relative to the CPI. But any arbitrary value for the CPI could be chosen and all real impacts would remain exactly the same.[51] The modeller can assume an annual inflation rate above, below, or exactly on the RBA's target rate and it would make zero difference to any quantity or real economic variables in the model. Moreover, the modeller can choose a different price to be fixed at 1, such as the nominal wage, and all real impacts would remain exactly the same.[52]

The modellers can get away with assuming inflation has no impact on real economic variables because the representative household and businesses in the model are assumed to change behaviour only in response to changes in the relative prices of goods and services. When all prices move in the exact same direction the representative household simply cannot change behaviour. Again, as discussed in the previous section, money, and the price level, are simply assumed to be neutral.

While the assumption of money neutrality is useful in theory, households in the real world often make economic decisions based on the nominal values of different variables. Households are said to display some level of *money illusion* where they view their economic situation – incomes, wages, wealth, and prices – in nominal rather than real terms.[53] For example, house prices increasing at the same rate as inflation may lead households to think they are wealthier leading to higher consumption expenditure. Or households may perceive a 5% wage increase during a phase of 6% inflation as a good pay rise, when in reality real wages have gone backwards. More generally, households may form opinions that weigh on economic decisions, and voting intentions, with reference to one or a few key important prices like energy prices, having not read the latest ABS data that suggests all prices are increasing. Importantly, the theory of the NAIRU used by the RBA to set interest rates depends on assuming that money illusion is a real phenomenon.[54]

[51] KPMG Econtech (2010), p.26

[52] Another homogeneity test, particularly in global CGE models, is to increase all exchange rates by 10% and check to ensure all quantity variables remain close to zero.

[53] Investopedia (2024) *Money Illusion: Overview, History and Examples*, https://www.investopedia.com/terms/m/money_illusion.asp

[54] See later sections for more details on the theoretical conflict in many CGE models that assumes the NAIRU on one hand, but on the other, also assumes inflation has no impacts on real economic variables.

The consequences of assuming inflation is irrelevant

The willingness of CGE modellers, and their customers in the policy community, to rely on the assumptions that inflation imposes no real costs on the economy raises significant questions about why successive governments and the RBA are so concerned about inflation and so determined to lower it into some arbitrary range.

Is it a case that one set of economic theories about inflation is suitable for some areas of the government's economic policy debate, while another set of theories are appropriate for other sectors?

If it is widely believed that inflation can impact real economic variables, as most economists at Treasury and the RBA seem to, then it seems unsuitable to use economic models to justify policy changes, or new fossil fuel projects, that assume inflation has no impact on real variables and economic outcomes.[55] If those policies or projects do indeed cause inflation, and in turn impact real economic outcomes, then the models are mis-specified and the results are clearly inaccurate.

Importantly, it does not take an extensive examination of Australian economic and political history to make the case that while CGE models may predict taxation and policy changes with significant effects on the CPI are of little concern, the political and economic reality is significantly different. The Henry Tax Review, and the many before it, had advocated for higher and broader GST-style taxes in large part because of their supposed non-distortionary impacts. But the reality of increasing Australia's GST from zero to 10% was anything but smooth or non-distortionary. After nearly losing the 1998 election with the GST policy, and within a year of its introduction, in 2001 the Howard government, facing an inflation spike and rapidly escalating (nominal) petrol prices, rushed to remove fuel tax indexation to ease inflation pressures and restore flagging approval ratings.[56] To be clear, the CGE model used by the Henry Tax Review, and other previous Treasury modelling exercises, explicitly assumes that there can be no price spikes, profit gouging, or changes in consumer behaviour after the introduction, or increase, of a broad-based consumption tax. It is perhaps unsurprising to non-modellers that no broad-based tax reform has been seriously considered since.[57]

[55] The RBA, Treasury and various consultants do use economy-wide models, of various types, that do model some of the impacts of inflation, such as the RBA's Martin model. These models, however, are typically used for forecasting exercises, not policy change proposals.

[56] Wright (2022) *2001: The Year Howard Drew a Line in the Sand and Transformed Australia*, Sydney Morning Herald, 1 January 2022, https://www.smh.com.au/politics/federal/2001-the-year-howard-drew-a-line-in-the-sand-and-transformed-australia-20211223-p59jwv.html

[57] Hon. Bill Shorten went to the 2019 Federal Election with a policy of broad ranging tax reform, but not a proposal to change to any broad-based tax, rather a few specific tax changes. Either way, the policy was not approved by the voting public.

The reality is that average prices (inflation) matter both economically and politically, and some prices matter much more than others. CGE modelling exercises that assume inflation is costless, should come with clear and prominent warnings that all inflation and interest rate impacts are explicitly ignored, especially when such models are used to show that tax changes like the GST, which inevitably cause inflation, are good for the economy.

COMPANIES MAKE ZERO ECONOMIC PROFIT

A common assumption in most CGE models is that profits in each industry are zero. More precisely, because of the underlying assumption of perfect competition, CGE models also have a zero economic profit condition built into each industry in the model.[58]

Economic profits, as opposed to accounting profits, are the profits earned after the opportunity costs of using capital in a particular industry are fully accounted for.[59] That is, economic profits are the profit above the minimum profit that is required to pay for the capital used in each industry. In a similar manner that wages are what a firm pays its workers to keep them on-site and working each day, economic profits are the profits beyond the minimum that would be required to stop the capital from the equivalent of looking for a better job in a different industry. Economic profits are also known as super-normal profits. Normal profits reflect the opportunity costs of using capital in other industries and are usually represented as the risk-weighted market rate of return.

In CGE models, economic profits are assumed to be zero because the perfect competition assumption holds that new entrants will be attracted to any industry in which super-normal profits are being earned by any firm. In turn, new entrants expand production, leading to lower prices and lower profits for all businesses in that industry, a process that continues until there are zero economic profits.

While the assumption of zero economic profits is questionable, it is no more or less questionable than the underlying perfect competition assumption on which it is based. Perfect competition rarely exists in real economies and in turn the assumption is of little value in analysing large parts of the Australian economy. That said, most modellers believe that such simplifying assumptions are necessary to make complex models mathematically solvable in terms of producing precise, if not accurate, results.

Leaving realism aside, as economists are often prone to do, the bigger problem when it comes to the zero profits assumption is that despite the assumption, when they are constructing their CGE models the modellers rely heavily on databases of actual companies that make considerable economic profits. As noted previously, the fundamental building

[58] Verikios, Hanslow, Mariano and Clements (2021)

[59] Clark (2018) *Whole-of-economy modelling: Beyond the black box,* Queensland Productivity Commission – Staff Research Paper, https://s3.treasury.qld.gov.au/files/Research-Whole-of-economy-modelling.pdf

blocks of CGE models are the input-output tables constructed by the ABS. As these tables are a statistical representation of reality, and uncontentiously, include data from companies that make significant economic profits, the data fed into CGE models explicitly contradicts the theoretical assumption within the model that no such economic profits can be earned.

The CGE modellers typically make little effort to remove the super-normal profits from the input-output tables before using them in the CGE models.[60] Even worse, if CGE modellers did seek to make such adjustments, then they could no longer claim their models are built upon an accurate description of the Australian or global economies at certain point in time. The underlying database would be just a theoretical construct to suit the underlying theory.

A practical example to keep in mind when understanding this issue is the banking industry in Australia. The so called Big Four banks make large and consistent profits. These are unquestionably super-normal profits since a tax is applied to these banks, introduced by a conservative Liberal government, to account for the funding and profit advantages they have on account of their size and status as being too-big-to-fail.[61] Quite simply, across the political spectrum and various financial system inquires, it is agreed that they are less risky but more profitable than their smaller counterparts. Such large and persistent profits are evidence of a clear market failure. These super-normal profits are reported by the ABS in the Australian input-output tables as a large gross operating surplus for the banking industry. The modellers then use that data, unadjusted, in the model's database to model the behaviour of firms that are assumed to be unable to make such profits.

To be clear, the model code assumes zero economic profits but the database that the code uses contains the very kind of profits that are assumed cannot exist. Therefore, the model code believes that all the profit recorded by the ABS in the input-output database is normal profit, reflecting only the opportunity cost of using capital in that industry, rather than super-normal profits caused by a range of market failures (barriers to entry, economies of scale, regulatory factors, and a range of government policies preventing more competitive outcomes to reduce the super-normal profits towards zero).

A tax on super-normal profits in the banking industry is clearly seen as desirable in Australia but it is simply impossible to make the case for such tax reform using a CGE model that

[60] One adjustment to the I-O table that is often done is to allocate some of the profits to the returns to the factors of production that are not reported in the I-O tables. Specifically, some of the gross operating surplus in the I-O table is allocated to the returns to land in the agricultural industries, and to natural resources in the mining and forestry industries. However, this process typically applies 'normal' return assumptions to land and natural resources meaning the super-normal profits remain attached to capital, even if there is a likelihood that the natural resource or land endowment is a primary reason for the super-normal profits.

[61] Parliamentary Library (2017) *The Major Bank Levy explained,* https://www.aph.gov.au/About_Parliament/Parliamentary_departments/Parliamentary_Library/FlagPost/2017/June/The_Major_Bank_Levy_explained

assumes super-normal profits cannot exist. On the contrary, a CGE model will inevitably show that a tax on the super-normal profits of the banking industry is harmfully distorting.

In theory, any super-normal profits earned in a CGE model would result in new entrants to the industry pushing prices and profits down. However, in practice, because the database on which CGE models are based include supernormal profits such as those earned by the Big Four banks, the CGE model cannot identify any excess profits in the input-output database and, in turn, no such capital flows or competitive effects can occur.

Consequences of the zero economic profit assumption

The main consequences of the zero profits condition are similar to the issues discussed in the previous section, namely that it causes capital and profit to be highly sensitive to taxes and policy changes.

Using the banking example, modelling a profits tax on the banking industry is akin to lowering the already minimum profit needed to keep the capital used for banking services in the banking industry. This would cause a shrinkage of the banking system as some banking IT infrastructure and branch office building would move onto better returns in other industries. The model fails to capture the fact that much of the profit comes from having a banking licence issued by the RBA, and related regulatory support, with the Big Four having the extra benefit of being perceived as too-big-to-fail.

The story is similar for other industries that may exhibit super-normal profits. For example, spikes in energy prices, global demand for natural resources, or regulatory restrictions on some forms of mining may cause temporary or consistent super-normal profits in the mining industry. But when a super-profits tax in mining is modelled, the model has typically been specified to assume that mining companies are only earning “normal profits” and then any additional tax imposed on them will lower returns below that required to justify keeping capital invested in the mining industry. In turn, the model will show that a super-profits tax on mining will lead to a reduction in mining activity. Again, when the model is specified this way, it is not proof that mining output will fall if a super-profits tax is imposed on mining; it is simply an assertion by the modeller. Put another way, unless there is a widely accepted measure of the size of the super-normal profits made by miners there will be no way to model the potential impact of a super-profits tax on the mining industry.

Overall, the assumption of zero economic profits makes CGE models overly sensitive to movements in the price of capital so policies that are assumed to affect profits lead to bigger model results than would likely be the case. In reality, the super-normal profits are often fixed in place, exist as a result of being in a specific industry, under specific regulatory arrangements, and certainly are not transferable to other industries. For example, the companies running the Big Four banks would not enjoy the same level of super-profits if they switched into the fruit picking industry, no matter how good the CEO believes

themselves to be. The super-normal profits exist because the CEO operates in banking, and holds a scarce banking licence, and not a result of astute business decision-making, nor the results of considerations of relative risk-adjusted rates of return across various industries. But, of course, in CGE models, all executives, in all industries, deliver the same risk-adjusted rate of profit to their shareholders, making the large CEO salaries that exist in reality particularly hard to explain.

The standard assumptions in CGE models ensure any policies that might lower profits will generate negative economic outcomes and, in turn, it is of little surprise that any proposed policies that affect profits result in multiple corporations and their lobby groups lining up to employ CGE consultants to show how bad proposed policy will be for the economy. And any broad-based review of taxation done using CGE, such as the Henry Tax Review, invariably leads to proposed tax changes on all the other factors of production that are supposedly less mobile than capital, which is effectively assumed to always and everywhere be earning the "minimum wage" of capital, rather than the super-normal profits observable in the model's database.

CAPITAL GOODS CAN BE USED, AND RE-USED, FOR ANY PURPOSE AT ANY TIME

Capital goods are defined as "produced means of production", that is, things that are made in order to make it easier to make other things. For example, while it takes time and scarce resources to make a plough, a tractor, or a granary, once built, all of these produced means of production can be combined with labour and land to produce far more wheat than would be produced if farmers only used their own hands to plant, harvest and mill their crop. The willingness and ability to spend 10 hours making a tool that can save 1000 hours of labour over the life of the tool was central to the shift from hunter/gatherer economies to agrarian societies. In turn, the willingness and ability to build steam engines and factories led to the Industrial Revolution. Investment in capital goods, and the improvement of those capital goods, lies at the heart of productivity growth, economic growth and, in turn, of CGE models.

Perhaps unsurprisingly, the definition and measurement of capital with CGE models is much simpler than in the real economy. The KPMG CGE model, for example, defines capital as "physical capital [that is] split into two different types. These are:

1. Structures – Residential and other
2. Other capital – which is all other capital goods, such as motor vehicles, machinery and computers"[62]

[62] KPMG Econtech (2010), p.34

Put simply, according to the KPMG model there are only two kinds of capital goods in the Australian economy; structures and everything else, where "everything else" includes shovels, tractors, grain silos, blast furnaces, LNG export terminals, computers, power stations, intellectual property, and roads.

Having assumed that all of these forms of "non-structure" capital are "the same" the KPMG CGE model assumes that it is not just possible, but costless, to convert an LNG export terminal into a solar farm. As discussed below this leads to a major risk of policy makers underestimating the risk of investing in stranded assets as, in a CGE model, there can be no such thing as a stranded asset. Just as swords were once beaten into plough shears, CGE models assume that coal mines can be converted into hospitals, albeit with less effort than required by a blacksmith to repurpose a sword.

The authors of the original neoclassical economic theories, writing in the early days of the Industrial Revolution, were focused on the plausible idea that the physical capital produced in that era, such as relatively simple tools, warehouses and buildings, could be repurposed for a range of tasks to make a range of goods and services. The idea was that physical capital had some degree of mobility or substitutability so that it could be moved between tasks in response to changing economic conditions at relatively low cost.

However, if we move from the time of Adam Smith to modern industrialised economics, the complex nature of modern capital equipment means that it has steadily become far less mobile and substitutable. If the $60-billion-worth of labour, steel and concrete spent on export gas terminals in Gladstone in 2016 is not used to export huge volumes of gas its demolition costs will likely be greater than the scrap value of the enormous amount of steel pipes it contains. In short, most major capital projects are entirely useless for anything other than their designed purpose.

Ironically, while the mobility of financial capital such as cash, shares and bonds (which are not included in CGE models) is at an all-time high, the usefulness of an assumption that physical capital is highly mobile/substitutable is at an all-time low. Keep in mind, financial capital, which is very mobile, is assumed not to exist in CGE models.

While much has been made post-COVID-19 of the dangers of long supply chains, (despite the low potential production costs associated with those long supply chains) there has been scant attention paid to the fact that the CGE models that have been so central to building the case for globalisation explicitly assume that if any link in these long supply chains breaks they can be instantly replaced, at near zero cost, by any other domestic or international facility.

In short, CGE models are based on the assumption that supply chain risk cannot exist as all means of production can be repurposed.

Anyone who has seen an Amazon distribution warehouse, or a modern container port, might rightly question the usefulness of assuming that the short terms cost savings from economies of scale will always exceed the risks of such hubs ceasing to exist and/or operate.

Modern capital equipment is so complex, and so large, it often simply cannot be used for anything other than its original intended design purpose. For example, integrated circuit fabrication plants, costing many billions to construct, cannot do anything other than produce integrated circuits. Indeed, entire new factories are often required to be built simply to manufacture the next generation of chips.[63]

To be clear, the fact that money and financial assets can now be moved around the world instantaneously is of no relevance to either CGE models (which assume no such assets exist) or to the real economy (who can in no way substitute more money for a shortage or port cranes in a country with no factory to make port cranes).

Despite the real-world observation that modern-day capital equipment is not mobile, CGE models still assume a high level of capital mobility. For example, in the KPMG Econtech CGE model "capital is treated as perfectly mobile" and "this mobility is generated by the international competition for funds".[64] This simply means the model assumes not just that blast furnaces can be readily repurposed into solar panels, but that Australian blast furnaces can be repurposed on Chinese soil as computer chip factories. Put another way, the model assumes that blast furnaces can be moved around the world as easily and as quickly as an American equity investor in Woolworths can liquidate their shareholdings and receive the payment in US dollars.[65]

Consequences of assuming all capital goods can be repurposed

The consequences of explicitly conflating the mobility of financial capital (which is not in the model) with the mobility of physical capital (which in the case of an airport or road is completely immobile) are as broad as they are significant. They fall under two broad categories:

[63] Tembey, Dahik, Richard, Rastogi (2023) *Navigating the Costly Economics of Chip Making*, https://www.bcg.com/publications/2023/navigating-the-semiconductor-manufacturing-costs

[64] KPMG Econtech (2010), p.21

[65] To be certain, some CGE models, typically more detailed single-country models, do have more sophisticated capital markets where industry-specific capital goods are modelled, alongside the perfectly mobile traditional economy-wide capital. In such models, however, there is still a relatively high level of substitutability between industry-specific capital and economy-wide capital and all factors of production, and the costs of stranded assets are rarely accounted for. Moreover, the industry-specific capital can be marginally increased/decreased with industry output rather than the reality of modern-day industry-specific capital which is typically *lumpy* in nature involving complex, all or nothing, final investment decisions.

1. **The costs of structural change are widely underestimated.** When capital is assumed to be highly mobile it is relatively easy and cheap to transform the economy from doing one thing to doing another. For example, shutting down coal-fired power stations and building nuclear power plants is relatively easy in CGE models as the "lost" capital from the coal plant is simply re-used in the nuclear plant. Such an assumption means there are no stranded assets when the industrial structure of an economy changes. Similarly, any *big-new-project* has relatively easy access to sufficient quantities of existing capital from other industries by simply bidding up, marginally, the average rental price of capital equipment. That is, in CGE models if there is a big increase in mining construction activity there is never a shortage of concrete pumps or tunnel boring machines. All that would happen in the model would be a slight increase in the average price of capital equipment, and capital from all sorts of industries, from cafes, childcare centres, and consulting offices, would simply be transformed at zero cost to capital equipment for the mining industry.

2. **Potential movement of factories, mines and other capital equipment is overly sensitive to tax policy changes.** Since physical capital is assumed to be so mobile, any policy that decreases the returns to, or increases the price of, capital will lead to relatively large negative economic impacts as the CGE model assumes physical capital will quickly and cheaply relocate to where the returns are better.[66] To be clear, in a CGE model, a tax on the mining industry would effectively result in some mining company dismantling some of their mining equipment, transporting it to a port, shipping it overseas, and building a new mine without incurring any transport costs.

Similarly, despite the construction costs of an LNG liquefaction plant being in the tens of billions of dollars, CGE models typically assume that increasing taxes on the returns to capital in LNG industry will see a reduction in the size of that industry as the capital quickly and easily moves to locations where the tax increase does not apply. The CGE models assume a flight-of-capital whenever taxes on capital change. Again, while a flight-of-capital maybe possible for financial capital, it is almost impossible with complex physical capital equipment. The policy advice that typically flows from the use of CGE models with assumptions of a high degree of physical capital mobility is that tax increases to capital are more disruptive to the economy compared to taxes on the other factors of production such as land and labour that are assumed to be less mobile. In reality, labour is now far more mobile than physical capital in most industries.

The CGE modelling backing the Henry Tax review recommendations clearly illustrates the effects of these assumptions. None of the 18 modelled taxes showed any final incidence or burden on capital since the modelling simply assumed that any tax on capital will drives

[66] KPMG Econtech (2010), p.7

capital to move.[67] Similarly, the review found that four of the five "worst taxes" (corporate taxes, payroll tax, insurance tax, and fossil fuel royalties and excises) were bad because so much capital would leave Australia in response to the new tax measures partially or fully aimed at capital.[68] Again, this is based on the confusion over financial capital and physical capital.

Put simply, the simplistic assumption that all capital goods are substitutes for all other capital goods means that CGE model significantly underestimates the difficulty of transforming assets from one purpose to another while significantly overestimating the likelihood that accompanies will pack up and leave the country if tax or wage rates increase slightly.

[67] KPMG Econtech (2010), Table 8, p.7

[68] KPMG Econtech (2010), Table 5.1, p.44

The important, but rarely discussed, issue of the reference case

To answer questions like “Is a four per cent pay rise a lot or a little?”, economists have to also ask “compared to what?”. In Australia today, nominal wages are rising rapidly by historical standards, but inflation is rising faster than usual, making it important to consider wage growth compared to inflation. Other possible comparators include profit growth, historic wage growth, average wage growth for all Australians or the wage growth of workers with similar skills. All numbers need to be placed in some form of context, and one of the most powerful, and poorly understood, tools that CGE modellers have is the power to decide what to compare the impacts of a policy or project they are modelling to. Put simply, modellers don’t just decide on the assumptions required to estimate the potential costs or benefits of a policy or project, they decide on what to compare the size of those costs and benefits to. The modeller decides what perspective the reader should view a policy or project from, in order to “help” the reader understand its relative size.

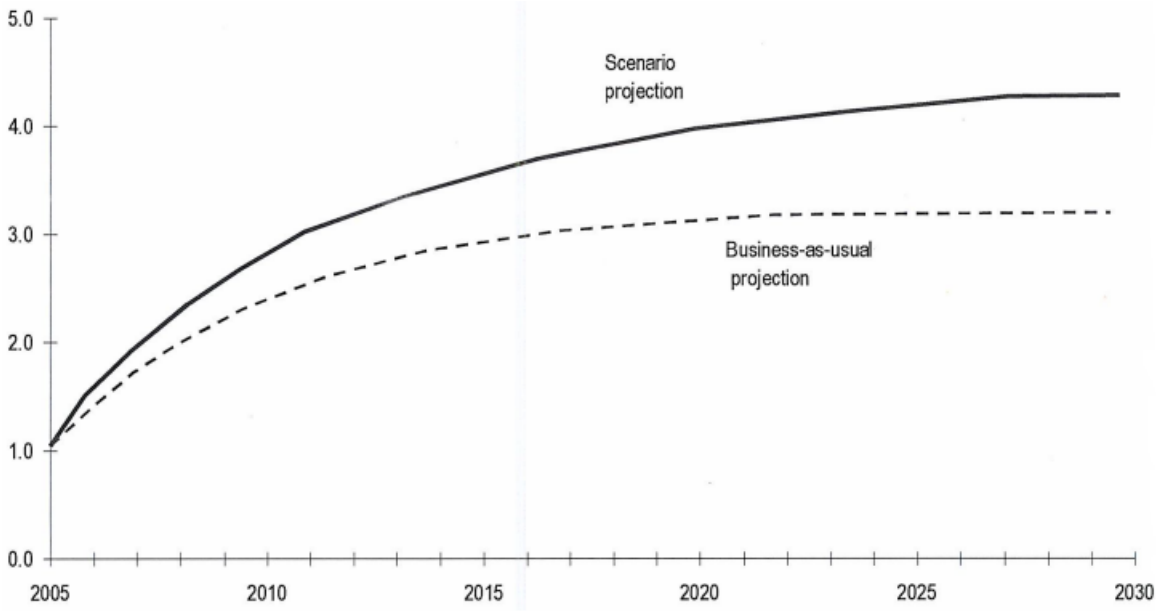
Just as a teacher may look tall when standing next to primary school students but short when standing next to other teachers, the economic benefits of a new coal mine or tax change can be made to look large or small by simply deciding what to compare it to. In CGE modelling, it is the choice of reference case that largely determines the perceived size of the economic impact of the change being modelled. The reference case, or the business-as-usual (BAU) scenario as it is sometimes called, is used to provide a benchmark against which policy changes can be compared.

That is, when a CGE modeller reports that a new policy will “create 10,000 jobs” or “boost GDP by $10 billion dollars”, these numbers can only be generated relative to something, namely the reference case or BAU scenario. But while the choice of reference case has a big impact on the conclusions of any modelling, the details of how the reference case was generated are rarely discussed by the modeller or those relying on the model results.

To be clear, the users of a CGE model must have strong faith that the modeller’s ability to both predict how the size and shape of an economy will evolve over the next 10 to 50 years *and* in the modeller’s estimates around the impact of the modelled policy change.

Fans of the *Back to the Future* movie trilogy would be familiar with the concept of parallel timelines where small changes in the past can lead to very different outcomes in the future on different timelines. The protagonists in *Back to the Future Part 2* judged how bad the new *distorted* timeline was with *reference* to the same point in time in the *normal* timeline. This is same way in which CGE results are interpreted (**Error! Reference source not found.**).

Figure 1: Interpreting CGE modelling results



Source: Cadence Economics (2018) Expanded Description of CEGEM, https://www.aph.gov.au/-/media/Estimates/economics/supp1819/TabledDoc_10.pdf, p.5

When CGE results are presented relative to a BAU scenario of what the future should look like (such as without the policy change or new project being modelled) then the assumptions the modeller makes about the BAU scenario are just as important as the assumptions the modeller makes about how the policy/project will impact on the economy. Put simply, how good or bad a policy change/new project appears depends entirely on the assumed position of the BAU scenario at the future time where the policy change has maximum effect, or construction of the big-new-project is completed and fully operational.

Economists are notoriously bad at predicting the future and few economists would claim to be able to accurately predict the shape and size of the economy in a decade's time or more. Indeed, as can be seen from each year's Budget Papers, most Treasury departments fail to predict GDP, inflation, unemployment, the exchange rate, or the budget deficit with much precision over 12 months. But despite the widely accepted inability of economists to predict the future, CGE modellers are typically making two sets of predictions at the same time: namely, predictions about how the economy will grow and evolve over coming decades *and* predictions of how a hypothetical change to policy will reshape their original prediction. Put simply, it takes as many modelling design decisions and assumptions to generate a reference case as it does to make the new scenario being modelled. Yet policy/project proponents, or their consultant modellers, generally spend much less time discussing the assumptions that underpin their precise forecasts of the growth rate of every industry in the economy over multiple decades that underpin the reference case than the new scenario.

In practice, the reference case is rarely discussed, often passed off in a paragraph or two noting that it follows long-term economic trends. For example, the Deloitte CGE modelling

of the development of Beetaloo Basin natural gas resources in the Northern Territory for the Department of Industry, Science, Energy and Resources included a single short sentence on the BAU:

> The business as usual scenario is based on historical data embedded in DAE-RGEM.[69]

But the future is rarely a copy of historic long-term trends, or a reflection of the data contained in a CGE model's starting year input-output table. More concerningly, any study of large-scale fossil fuel projects requires careful consideration of climate change policy and its impacts on both the BAU and the policy scenario, but such work is rarely, if ever, attempted.

Consequences of ignoring how the reference cases are created

A significant example of the consequences of BAU choice was the modelling of the National Broadband Network (NBN). Following the election of the Rudd Government in 2007, a significant body of modelling was undertaken to estimate the economic impacts of the proposed high-speed communications network. The most important question was not whether high-speed internet would work, since the technology already existed, but the costs and benefits to the economy of different policies to roll out the NBN.

From a CGE modelling point of view, the most important question was: what internet speeds would be achieved if the NBN did not go ahead, particularly in highly populated areas? To be clear, it was impossible to model the benefits of the NBN investment without first predicting how fast the internet would be in the coming decades in the absence of the NBN investment.

It is hard to overstate the importance of the assumption, made by economic modellers, about the rate at which private phone companies would roll out faster internet cables in the absence of the Commonwealth-funded NBN. A particular challenge for modelers and policy makers alike was the fact that, without the NBN, there was the strong chance that internet speeds could be much higher, much sooner, and much cheaper in capital cities without the NBN than with it. If modellers assumed that inner-city residents would get fast cheap internet without the NBN, then rather than showing economic benefits, the economic modelling of the NBN would likely show little benefit, or even economy-wide costs associated with massive public investment.

Modelling the potential costs and benefits of the NBN was particularly challenging since the model predicted, in some scenarios, that the biggest positive economic impacts, even in

[69] Deloitte (2020) *Report on the Development of the Beetaloo Sub-basin*, https://www.industry.gov.au/publications/beetaloo-sub-basin-gas-development-study

regional areas, were achieved from installing relatively higher internet speeds in the more populated areas, compared to rural areas, and doing so as soon as possible.[70] Designing the BAU in one particular way could make the NBN look worthless, in another way it would make the project look successful.

In the end, most modelling said the NBN was worthwhile, while in reality many highly populated urban areas in non-marginal seats would not get connected to the NBN until just before the arrival of COVID, while in the meantime the private sector roll-out of high-speed internet services, particularly for residential services, ground to an almost complete halt.

The key point is that selection and design of the BAU drove the results of the modelling. The future world with an NBN was relatively easy to envisage, high speed internet for most of Australia. The alternative reality was difficult to foresee as no one knew exactly how private providers of high-speed internet would have behaved in the absence of the NBN. But it was the assumptions made about that alternate reality (the BAU) that determined whether the model presented the NBN as a worthwhile investment. In effect, to make the NBN appear more beneficial, the BAU had to assume the private sector would not invest heavily in high-speed internet in high density, high-income inner-city areas. Such pessimism about the likely behaviour of the private sector helped inflate the impacts of a NBN rollout plan, but to be clear, it was the pessimism in the BAU scenario that determined the size of the modelled benefits.

[70] See for example: Access Economics (2010), *Economic Impact of the National Broadband Network in Queensland,* and Access Economics (2009), *Impacts of a National High-speed Broadband Network*. Note: According to the modelling, since rural areas consume a relatively small share of goods and services supplied from the cities, the benefits of higher internet speeds and a faster roll-out in the cities becomes more quickly encapsulated in the products consumed in regional areas. Rural areas receive some of the benefits of the NBN long before a city-first rollout pattern reaches the rural areas.

Only successful projects are modelled

It is impossible to model a bad idea in a CGE model. Investors are assumed to be rational, and rational investors would only invest in good ideas.

CGE modelling is often used to build a public and political case for big new projects ranging from the Adani coal mine, mining for gas in remote Northern Territory and the NBN. It is likely that in the not-too-distant future we will see CGE used to "show" the economic benefits of nuclear power. The ability of CGE models to present the personal interests of the project proponents as being in the public interest is arguably one of the main reasons government and major project proponents are willing to pay up to $1 million for modelling. Significantly, CGE modelling is almost never used by private companies to help make their own internal decisions, but they often use modelling to convince governments and the public of the virtue of their projects. To be clear, companies almost never use CGE modelling to help evaluate a project for themselves.

When a new project is modelled to determine if the economy-wide impacts are positive, the project can be fed into the model in a variety of ways. The model is then re-run so it can be compared to a BAU scenario without the new project.

A key decision that modellers need to make, one that is largely invisible, is how the new project should be described in the model. If a highly profitable project that successfully employs many people and sells all of its output to willing customers is inserted into the model, then the model will invariably show positive economy-wide impacts. By definition, adding a profitable, productive new project that draws highly mobile physical capital and labour away from less productive uses will increase GDP.

But if an unprofitable project that tries to sell products that no one wants is inserted into the model, then the model will literally be unable to run as CGE models are based on the assumption that rational agents with perfect information seek to maximise profits and would never make a bad investment. In turn, trying to model the impact of a bad idea simply causes an error as the models are not designed to handle negative profits, or unsold goods, or markets that do not clear in the way described by neoclassical theory.

So only successful projects are modelled, and all modelled projects are "good for the economy". In turn, it should come as no surprise that CGE models never find that a new project is a bad idea or bad for the economy. The fact that the project can be modelled inevitably means it must be good. To put it more technically: only projects that are assumed to be successful at the microeconomic level are inserted into CGE models to estimate their

macroeconomic impacts. It is in turn practically inevitable that successful projects at the microeconomic level are also successful projects at the macroeconomic level.

While some of the more detailed CGE modelling projects do analyse the microeconomics of various scenarios for new projects, it is only the successful and profitable scenarios that are ever modelled in the CGE framework and presented as "proof" that the project should go ahead. For example, the ACIL Allen modelling of shale gas development in the Northern Territory extensively examines the likely gas market scenarios of different production volumes before using CGE modelling.[71] But again, only profitable scenarios were modelled in the CGE framework.

More often than not, the microeconomics of a specific projects are simply ignored in published CGE modelling reports. A project is simply assumed to be successful by the modeller and then when modelled it unsurprisingly predicts positive economy-wide impacts. For example, a Deloitte Access Economics modelling project of essentially the same NT shale gas development follows the popular, less time-consuming approach of simply assuming a successful project at the microeconomic level and feeding the successful project into the CGE model. At least in this example, Deloitte's methodology section clearly states its heroic assumption, which is not the case for many projects:

> Taking market prices, transport and processing costs as given, it is assumed that producers can supply at the residual cost (i.e. the extraction cost).[72]

What the above quote shows is that the CGE model does not determine if a project will be successful in terms of direct employment, output, and profits. The modeller makes that decision before the model is even run. The CGE model simply estimates the flow-on impacts of having another successful project in the economy. It is then no surprise that whenever a new project is modelled in a CGE model, the economy-wide impacts are always positive, and the project is subsequently promoted as being worthy of government approval or assistance. It is little wonder then, why proponents of new projects both in government and the private sector are enthusiastic users of CGE models.

[71] ACIL Allen (2017) *The Economic Impacts of a Potential Shale Gas Development in the Northern Territory*, https://frackinginquiry.nt.gov.au/news?a=456788

[72] Deloitte Access Economics (2015) *Economic impact of shale and tight gas development in the NT: APPEA*, p.15, https://energyproducers.au/wp-content/uploads/2020/06/APPEA_Deloitte-NT_Unconv_gas_FINAL-140715.pdf

Model results can be presented and analysed in misleading ways

> Another unfavorable outcome that happens frequently is that the model is fine, and the simulation is fine, but the analysis is trash.[73]

Dixon and Rimmer describe the importance of accurately and usefully explaining CGE model results for a broad, non-expert audience:

> Highly reliable models have been developed for predicting numerous physical phenomena, e.g. the motion of the planets. In these circumstances it is not important for the person generating the results to explain them to the person receiving the results. The results can simply be accepted. Economists have neither data nor behavioural theories of sufficient quality to allow them to develop models of high predictive power. Thus, they have an obligation to themselves and to their clients, to provide assessments of the results from the models.[74]

But rather than accept what Dixon and Rimmer refer to as the "obligation" to describe the limitations and results of modelling in a clear and fair-minded way, the reality in consultancies and government agencies involved in CGE modelling is that the analysis and presentation of results are usually well underway long before the modelling is finalised.[75]

In fact, much of a CGE modeller's time is spent tweaking results to fit the narrative that is already well established by report authors who start writing well before the results are finalised. Even if the headline numbers cannot be made as big (or small) as those desired by the client, almost any model result can be dressed-up in a range of ways, described in detail below, to make them suit the pre-determined narrative.

Put simply, the analysis and presentation of modelling results are vital parts of the modelling process. Decisions about which assumptions, and which results to focus on, and which to ignore, are key to the effectiveness of CGE modelling in building the political case for the narrative that figures such as Ken Henry and Brian Fisher (See *Importance of CGE in the Australian policy debate* section) have admitted are so important to build support for their preferred policy change or big new project.

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[73] McDougall (1993) *Uses and Abuses of AGE Model*, https://www.gtap.agecon.purdue.edu/uploads/resources/download/21.pdf

[74] Dixon and Rimmer (2002), p.21.

[75] One of the authors has worked as a CGE modeller in public and private sector roles for over two decades and has directly observed this pattern of work.

CGE modelling results can be easily presented in different or misleading ways because the results can be interpreted and measured so differently. For example, as shown above in Figure 1, the modelling generates two parallel paths (one with and one without the policy change being modelled) and the difference between those two paths can be measured in nominal dollars, constant dollars, percentage change, percentage of GDP, and so on. It is easy to make small annual effects seem big (for example by adding them up over 20 years) or to make big effects seem small (by expressing them as a percentage of a large number like GDP).

A particularly crass example can be found in ACIL Allen's CGE modelling of shale gas development in the Northern Territory. The report's executive summary presents employment impacts of different scenarios on page 6, with increases in "jobs" of between 2,154 and 13,611, which seems substantial in comparison to the NT's workforce of around 100,000 people. It is only on page 134 that readers discover the earlier numbers represented not numbers of ongoing jobs but "job years" and the number of actual ongoing jobs was estimated to be between 82 and 524.[76]

Different units of measurement can be used to highlight or conceal significant parts of the analysis, including percentage changes, dollars, growth rates and discounted net present value (NPV) values. Similarly, the modeller or their client is free to choose between similar sounding, but quite different variables such as GDP, GNP, GNI, or household incomes when deciding which to present. Few readers of modelling results would understand that consumer surplus is not included in GDP but is included in many measures of net benefit. But all CGE modellers know this, and they understand the significance for their customers of presenting the most favourable headline result. Put simply, all economic indicators have different strengths and weaknesses, and the modeller can simply choose the one best suited to the narrative preferred by the client or policy-maker commissioning the modelling.

EXAMPLE OF PRESENTATION OF MODEL RESULTS

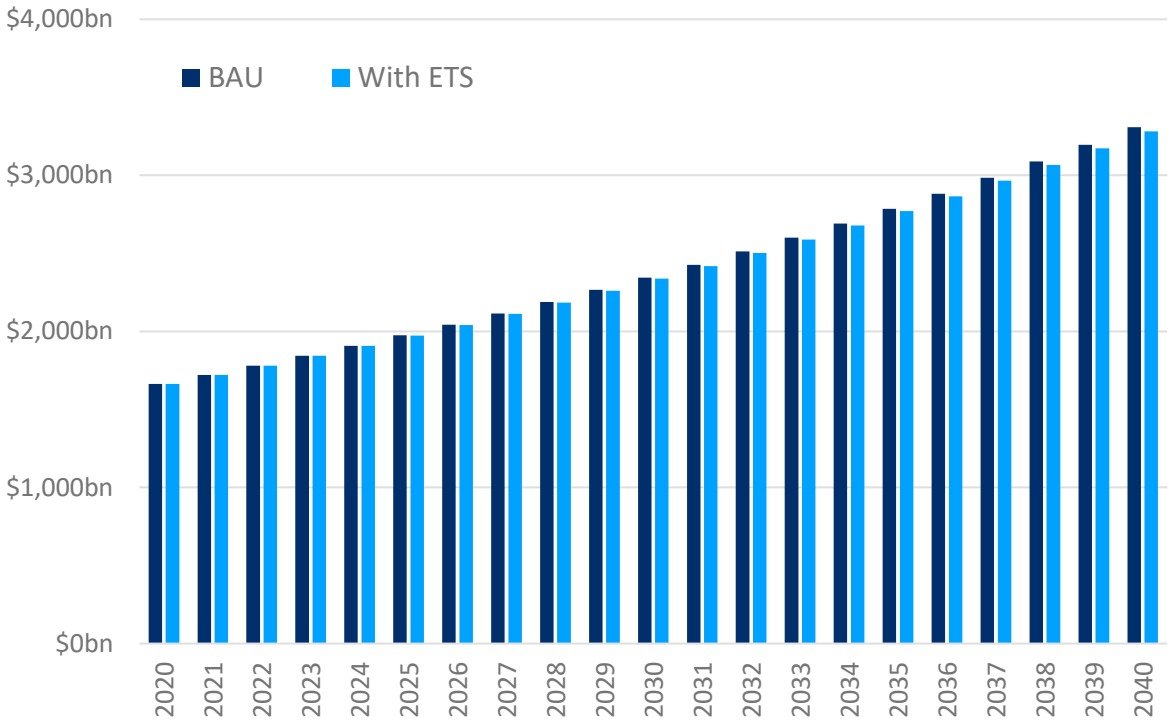
Leaving aside all of the assumptions described above, a simple stylised example illustrates just how much discretion economic modellers have in the presentation of results. Figure 2 below analyses the impacts of an emissions trading scheme (ETS) on real household disposable income in Australia, based on the work of Clark at the Queensland Productivity Commission.[77] It shows the two almost parallel timelines consisting of the reference case (BAU scenario) and the policy change scenario with an ETS. Figure 2 shows changes in disposable income, but the implications apply equally to any model variable. At the start of

[76] ACIL Allen (2017) *The Economic Impacts of a Potential Shale Gas Development in the Northern Territory*, https://frackinginquiry.nt.gov.au/news?a=456788

[77] Clark (2018) *Whole-of-economy modelling: Beyond the black box,* Queensland Productivity Commission – Staff Research Paper, https://s3.treasury.qld.gov.au/files/Research-Whole-of-economy-modelling.pdf

the modelling exercise in the year 2020, the value of real household disposable income is as reported by the ABS in National Accounts at $1,663 billion.

Figure 2: Stylised example of CGE modelling results, real household disposable income



Source: The Australia Institute projection using ABS (2024) and Clark (2018)

Figure 2 shows that over the period from 2020 to 2040, real household disposable income almost doubles to $3,308 billion under the BAU (no ETS) scenario. Figure 2 also shows that if an ETS is introduced, real household disposable income tracks the same path as the BAU until its assumed introduction in 2025 and then they diverges slightly over the years to 2040.

A visual examination of **Error! Reference source not found.** suggests that the impact of the ETS is relatively small yet these exact same results could be interpreted and described in any of the following ways:

1. The ETS would slow growth in household disposable income by only 1/20th of 1% out to 2040.
2. Under an ETS household disposable incomes would be 72% higher in 2040 than they are today.
3. The ETS would cause household disposable incomes to be 0.77% lower in 2040 than if no ETS existed.
4. The ETS would mean incomes would be $25 billion lower in 2040.
5. The ETS would result in a loss of income of around $184 billion by 2040.

To be clear, all five statements above accurately describe the results presented in **Error! Reference source not found.**, but they each create significantly different perceptions of whether the introduction of an ETS would have a large or small impact on the economy.

Put simply, regardless of the actual assumptions made in modelling, if a modelling client wanted to show that an ETS would have a small or large effect they would simply need to change the presentation of the results.

The "correct" way to present the results of such modelling is debatable, not least because option 5 also requires the use of a discount rate to accumulate the impacts across time. Of course, the introduction of yet another variable that can be tweaked to inflate or deflate the apparent impacts, outside of the modelling itself, creates even more scope for the CGE modeller to use subjective assumptions to have a big impact on "objective" modelling results. It is not unknown to use a discount value of zero to give the impression of far bigger impacts.[78]

While there is no one correct way to present results, most CGE modellers would initially judge the quality and the economic sense of their work based on option 3 in the list above. In presenting results using option 3 it would likely be presented more completely as:

> The ETS would cause incomes to be 0.77 per cent lower in 2040, compared to a scenario without an ETS.

This presentation is arguably the most technically correct way to interpret the results as it focuses on what is actually being modelled: two competing scenarios over time. However, this presentation still requires readers to carefully consider the values of two variables at a future point in time, one in each scenario, with further consideration given to the general growth path of that variable in the meantime. That is, the technically correct interpretation still leaves the impression that household incomes have fallen because of the ETS, when in fact the model predicts strong growth in both scenarios, just slightly less strong growth in a scenario with an ETS.

Importantly, in reality and without a time machine, it is simply impossible to jump between the two timelines, such that households would never be able to make the comparison as described. It is unlikely that households materially feel the difference between 3.5% and 3.45% annual growth in their real incomes over a decade.

It is highly significant to note that the modelled impact in Figure 2, and indeed most CGE modelling results, refer to changes in economic activity that are far smaller than the average GDP growth forecast error in Treasury Budget Papers.[79] Put another way, for the ETS

[78] For an example see: PwC (2022) *A nature-positive Australia: The value of an Australian biodiversity market*, https://www.pwc.com.au/government/A-nature-positive-Australia-The-value-of-an-Australian-biodiversity-market.pdf

[79] Treasury (2024) *Budget 2024-25 – Budget Paper 1, p. 265*, https://budget.gov.au/content/documents.htm

example above there would be a 50% chance that the BAU would grow faster than expected and that such windfall growth would dwarf the predicted cost of the modelled policy change. Few modelling results are ever presented in this context that the modelled impacts of a big policy like an ETS are often less than the average forecast error for GDP, to provide important real-world context.

The key point is that presentation of model results is another important and complex area of CGE modelling, open to easy manipulation. Modellers can present the story they, or their clients, have already chosen to tell. It is another demonstration that much modelling is simply a tool of persuasion rather than objective policy advice.

CGE models are based on conflicting theories

The fact that CGE models are built on economic theory is often described as a strength, and a source of objectivity, even when there is little empirical evidence to support such theories. As Clark puts it:

> The [CGE] models' behavioural rules are derived from economic theory rather than from time series data, allowing them to overcome the practical difficulties associated with IOE modelling and the limiting assumptions inherent in I-O multiplier analysis. By focusing on the structure and detail of agent-specific [theoretical] 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.[80]

In a physical science, like climatology, researchers are always testing their theories about how the atmosphere will respond to changes in variables such as CO2 concentrations or methane concentrations against real-world data. When there is a divergence between the data and the model then it is the data that takes precedence. In economics, however, theories like "perfect competition" or "rational expectations" can persist for decades, or centuries, long after their lack of empirical foundation has been established.

To be clear, CGE models are quite different to scientific models of physical science. CGE models are built on the basis of subjective assumptions and rather than being tested against a measured reality, they are typically evaluated by the modeller and their user against subjective criteria such as tractability, cost, usefulness and sometimes theoretical consistency.[81] However, despite the repeated references to the importance of theory in designing CGE models, in reality most CGE models are typically built on a raft of contradictory, and irreconcilable, theoretical foundations.

For example, CGE models typically rely on so-called "neo-classical supply side theory" to predict the level of GDP ten or more years into the future (the subjectively assumed long run) while using a demand-driven Keynesian model to predict fluctuations in the shorter term.[82]

[80] Clark (2018), p. 7

[81] Downes (1995) *An Introduction to the TRYM model – Applications and Limitations, p.20, https://www.sciencedirect.com/science/article/pii/S1474667017470881*

[82] Downes (1995), p.26

Put simply, a classical supply side model assumes that the level of GDP in the future can be predicted based on just three variables which the Commonwealth Treasury typically refers to as "the three p's", namely:

- population
- (labour force) participation; and
- productivity.[83]

That is, if the size of the workforce and the output of each worker is known, then GDP is simply equal to the product of GDP per worker and the number of workers. That said, it is crucial for readers of CGE modelling reports to realise that literally all of the three p's are the best guesses of the modeller rather than outputs of the model itself. To be clear, it is the modeller, not the model, who chooses the assumption for population growth, the labour-force participation rate and the rate of change of productivity, and *it is these three assumptions alone that are entirely responsible for predicting GDP in the future*. Literally all the thousands of other assumptions and equations in a CGE model do is allocate the predetermined level of GDP between different industries and factors of production.

For the avoidance of any doubt, using a classical supply side theory to model the long level of GDP is simply the process of recycling assumptions about output per worker and the number of workers into a conclusion, which is the product of worker numbers and output per worker.

To be clear, if the modeller assumes the future population growth and assumes the future labour force participation rate, then they have assumed the future size of the labour force. And if the modeller then assumes the future rate of productivity growth, then they have actually assumed how GDP per worker will grow over time. And GDP per worker multiplied by the number of workers is, by definition, GDP.

Of course, everyone, including CGE modellers, knows that economies are much more unstable and unpredictable than the classical long run makes them seem, which is why their models typically include a Keynesian short-run that allows for the more familiar business cycle with its booms and recessions and changes in unemployment.[84] But this is where the theoretical contradictions appear.

Leaving aside the fact that CGE models typically assume the things that usually cause short-run fluctuations, such as changes in interest rates, investor confidence, and stock market fluctuations, literally do not exist or matter, the fundamental contradiction at the heart of

[83] Treasury (2023) *Intergenerational Report 2023 – Australia's Future to 2063, p.27, https://treasury.gov.au/publication/2023-intergenerational-report*

[84] But while unemployment is allowed to vary, as discussed above, inflation is excluded from the model, so while Keynesian models of unemployment involve changes in inflation, the 'theoretically consistent' CGE models do not. '

CGE models is that the cyclical unemployment that is allowed to exist in the short-run Keynesian model is explicitly assumed not to exist in the long-run classical supply side model.

Because CGE models are using a classical long-run supply model to predetermine what the level of GDP will be in the future, it inevitably means that the model will show that there is literally no long-run impact on GDP from a period of high unemployment. That is, according to CGE models, there is no long cost of a period of high unemployment. Were RBA policy decisions and interest rates to exist in a CGE model (which they are assumed not to) any policy-induced "recession we have to have" would have zero long-run impact on GDP.

But, to be clear, CGE models do not predict or show that periods of high unemployment will have no long run effects on GDP, they explicitly assume it will not. In reality, there is strong evidence that periods of high unemployment can cause significant labour market scaring, declines in the size of the capital stock and lower productivity growth.[85]

Leaving aside the conceptual and empirical problems with building a CGE model on the basis of a long-run supply model that assumes unemployment never happens, and a short-run Keynesian model that assumes it does, there are very significant problems when policy makers confuse how the model works with how the economy works.

For example, when Treasury say there are only three things that matter in the long run: population, participation, and productivity, they are describing how the model works, not how the economy works. For example,

> This framework is summed up in the 'Three Ps': the truism that our ability to satisfy the material aspirations of future generations of Australians depends upon our population, labour force participation, and productivity. The central message of the two intergenerational reports has been that our ability to satisfy those aspirations, and also to secure the long–term sustainability of the budget, depends on the pursuit of further productivity and participation–enhancing reforms.[86]

But this truism, and the economic models it is based on, says literally nothing about what determines population growth, participation rates, or productivity growth. Again, all three of the three p's are simply the best guesses of the modeller. They are subjectively plugged into the model, not results or conclusion of the model.

The power of the three p's in the model is enormous. For example, if the modeller personally believes that cutting income tax rates will lead to an increase in the labour force

[85] Day and Jenner (2020) *Labour Market Persistence from Recessions,* RBA Bulletin Sept 2020, https://www.rba.gov.au/publications/bulletin/2020/sep/labour-market-persistence-from-recessions.html

[86] Henry (2007) *Challenges confronting economic policy advisers*, Views from the Inside No. 3, Australian and New Zealand School of Government, https://anzsog.edu.au/app/uploads/2022/06/Views_from-the-Inside-3-Henry-2007.pdf

participation rate then the modeller can use their CGE model to show that cutting income tax rates will lead to an increase in GDP. But again, there is nothing inherent in a CGE model that shows cutting income tax rates will do a better job of boosting the participation rate than providing, for example, free childcare. Instead, like Dixon, the modellers need to explicitly decide to model the competing policy ideas and carefully analyse the model outputs.[87] Likewise there is nothing in a CGE model to capture the impact of inequality on economic growth, even though organisations such as the IMF now concede such a link exists.[88]

Indeed, when you hear an economist such as Paul Krugman say something like "in the long run productivity isn't everything, but it is nearly everything", what you are really hearing is that in a model that assumes population growth is beyond the influence of government and that productivity is the main determinant of the future level of GDP. But of course, CGE models do not have any ability to predict productivity growth; the future rate of productivity growth is simply a number assumed by the modeller.

Of course, the use of conflicting theories of the causes of GDP growth are not the only contradictory theories contained in CGE models. For example, despite CGE models assuming that inflation does not matter (see above), CGE models often contain add on "modules" or extra features in which it is assumed that inflation can have an impact on real variables. That is, there are often theoretical conflicts between the core of a CGE model that assumes inflation has no impact, and other parts of the model that do assume inflation has an impact on real outcomes.

The prime example of the contrary theoretical assumptions built into CGE models relates to the equations describing the behaviour of the labour markets in many CGE models. Many of these models assume that the labour market operates according to the theory of the NAIRU.[89]

As the name suggests, the NAIRU theory relies on the existence of inflation.[90] The basic idea behind the NAIRU is that there is an inverse trade-off between inflation and unemployment, such that if unemployment is too low, inflation will increase.

[87] Dixon (2020) *A comparison of the economic impacts of income tax cuts and childcare spending*, https://australiainstitute.org.au/report/a-comparison-of-the-economic-impacts-of-income-tax-cuts-and-childcare-spending/

[88] IMF (2024) *Income inequality,* https://www.imf.org/en/Topics/Inequality

[89] For example: Adams, Dixon, Horridge (2015) *The Victoria University Regional Model (VURM): Technical Documentation, Version 1.0*, https://www.copsmodels.com/ftp/workpapr/g-254.pdf, and Dixon and Rimmer (2002) *Dynamic General Equilibrium Modelling for Forecasting and Policy – A Practical Guide and Documentation of MONASH,* North Holland Publishing

[90] Investopedia (2024) *Non-Accelerating Inflation Rate of Unemployment (NAIRU)*, https://www.investopedia.com/terms/n/non-accelerating-rate-unemployment.asp

In CGE model documentation, the NAIRU theory is usually described as: in periods of above trend economic growth and low unemployment, workers predict higher future inflation and lower real wages and respond by demanding higher nominal wages today.[91] The higher nominal cost of labour causes firms to reduce their demand for labour, driving unemployment back to a level that does not cause inflation to increase. Unemployment continuously reverts back to a level that does not cause an increase in inflation: the NAIRU level of unemployment. The final result is that, in the long run, unemployment cannot fall below the NAIRU.

There are of course obvious problems with using a model that simultaneously assumes inflation has no real impacts as the foundation but then also assumes inflation plays a major role in determining the labour supply.

The solution to this dilemma, or inherent theoretical contradiction, is for the modeller to simply impose an arbitrary assumption about the size of the NAIRU into the model rather than try to actually incorporate the interaction between inflation and labour supply into the model itself. That is, as with the future population, future participation rate, and future rate of productivity growth, the modeller simply decides what level of unemployment they feel is consistent with the NAIRU and then adds some additional equations to the model to ensure that labour supply and labour demand behave in a way that is consistent with the NAIRU they have assumed to exist. To be clear, these additional equations do not capture the theory that underpins faith in the existence of a NAIRU as, again, the underlying CGE model assumes that inflation has no real impact. Rather, all the modeller is doing is artificially imposing (yet another) external constraint on how the model will work, albeit an external constraint consistent with a particular worldview about how the economy (and in turn the model) should work.[92]

Quite simply, if the core CGE model equations suggest that a new policy or big new project would increase the demand for labour and lower unemployment, there is another set of equations in the model that just push the labour demand curve back to where it began over, say, 5 to 10 years, to mimic the NAIRU theory. This means that while the results of the model may appear consistent with the existence of a NAIRU, the CGE model itself is not.

The existence of clear theoretical contradictions built into CGE models raises a number of questions including: Do the modellers know? Do the modellers care? And if neither theory nor empirical data are behind a CGE model, what is?

Do the modellers know?

CGE models are an impressive feat of intellect and pragmatism and there is no doubt their original architects understood the contradictions and limitations of the models they built. As

[91] Dixon and Rimmer (2002) p.205

[92] Dixon and Rimmer (2002) p.205 – 212

noted by Box and Draper back in 1987, "[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."[93]

That said, in recent years it has become increasingly common for those with qualifications in mathematics and programming, rather than trained economists, to be employed as economic modellers and it is not clear how aware of, or interested in, the theoretical underpinnings of the models such technicians are. This apparent disinterest is sometimes reflected in their modelling output. For example, it was common for ACIL Allen CGE modelling reports to publish "real employment" impacts.[94] Most economists would know that employment is always a real variable; that is, you would never adjust the number of employed people for inflation and in turn there is no such thing as nominal employment. But if a mathematician observes in the model code a summary employment variable that is being calculated as weighted-average across a numbers of industries by a value, dollar based, variable that is deflated by a price index, like the CPI, the mathematician may assume that it is some type of real employment measure, blissfully unaware of the economic theory, or even the ABS economic data.

Do the modellers care?

There is no doubt that some modellers are both aware of, and concerned with, the potential for models with contradictory theory to be misused/abused. Such modellers are working to refine their models in ways that improve their usefulness for genuine policy analysis. For example, Monash University's Centre of Policy Studies (COPS) has in recent years refined the treatment of gender in their model treatment of the labour market.[95] Similarly, other researchers have made extensive efforts to develop models that have a better explanation of the role of finance in modern economies.[96]

But despite these efforts there seems to be little research being conducted into updating or fixing some of the core contradictions, such as the assumption that inflation does not matter, or to model rather than impose, short- to long-run economic transitions, particularly in the labour market. Similarly, there appears to be little interest in removing/better describing the key role that a single guess/assumption about the long-run labour supply elasticity assumption (See Section 4 above) has on nearly all dynamic CGE modelling.

[93] Box and Draper (1986) *Empirical Model–Building and Response Surfaces*, p. 424, eBook, Wiley, New York

[94] See for example: ACIL Allen (2017)

[95] Dixon (2020) *A comparison of the economic impacts of income tax cuts and childcare spending*, https://australiainstitute.org.au/report/a-comparison-of-the-economic-impacts-of-income-tax-cuts-and-childcare-spending/

[96] Dixon, Giesecke, and Rimmer (2015) *Superannuation Within a Financial CGE Model of the Australian Economy*. Working Paper - Centre of Policy Studies, https://vuir.vu.edu.au/38798/

Does it matter if there are theoretical contradictions in a model designed to inform policy?

Economic models, no matter how many equations they contain, will always be an enormous simplification of the real economy. Likewise, given how imperfect and unsettled economic theory is, it should not be a surprise that any attempt to simultaneously model the behaviour of tens of millions of consumers and workers, millions of businesses, and their interactions with each other and the rest of the world may contain some contradictory elements of theory as the best theory of the labour market may be built on different assumptions to the best theory of investment.

But while conflicting theory may be unavoidable, misleading users about the usefulness of the model is entirely avoidable. The fact that a model has a long-run forecast of GDP that is entirely determined by the personal preferences of the modeller is mostly irrelevant when asking questions about how spending $50 billion on new fossil fuel projects in WA might draw workers away from renewable energy, infrastructure and manufacturing in other states. But to use a model that has an externally assumed level of GDP for 2030 to show that fiscal stimulus leads to no long-run change in employment and GDP but a long-run increase in the price level is dangerous, and likely deliberate.

Indeed, when the models are used to shape the narrative as outlined by Banks[97], the incentive to keep important assumptions and methodology choices covered up is strong. As Clark makes clear:

> 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 [or government's] interest[s] [are] unlikely to get repeat work [or performance reviewed favourably by supervisors]. 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.[98]

Quite simply in commercial modelling companies the pressure is often on modellers to deliver quick results with little fuss to support pre-determined outcomes. Such as an environment does not foster an open and transparent modelling process, let alone allow time to question, research and refine the limitations of the models.

Again, it comes back to the reality that these models, particular in Australia, are tools of the government, designed to speak the language of government for the government. When the politicians and the RBA pick and choose theories to suit a narrative, so too must the CGE models. They require a theoretical flexibility to match the political narrative they are

[97] Banks (2008)

[98] Clark (2018), p.3

designed to support. Otherwise, the models are consigned to academia and the consultants are not hired.

Conclusion

While this paper may be heavy reading for many non-modellers the eight key points are relatively simple:

1. CGE models are complex tools requiring a diverse range of skills to build, maintain and operate.
2. Australia has been a leading country in the use and development of these models for many policy questions over a long period of time.
3. Leading policymakers are open and clear that these models are used as a tool of persuasion of governments seeking policy change, stakeholders affected by policy changes, and those wishing for government support for large, often fossil fuel based, investment projects.
4. But the models, by themselves, do not deliver policy advice or investment recommendations.
5. The model results are 100% determined by the choices made by the modellers in designing and implementing the models.
6. Different choices create different model results.
7. Therefore, it is paramount that all consumers of model output are fully aware of these choices and the inherent limitations of the models. This is difficult, if not impossible, because the models are so complex.
8. To help overcome this problem, this paper outlined eight important areas where key assumptions and design choices are made that consumers of model output would not be aware of.

By the end, readers may have formed the view, as others have that, "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."[99]

We hope not. Applied CGE models remain an impressive feat of research that are able to deliver numerical estimates to complex policy questions, based on complex economic theory rarely discussed in undergraduate economics, using large, complex and messy real-world databases. When all users are aware of the limitations and assumptions involved, useful policy debates can and still do happen on the basis of their results

So, while it may be best for CGE modelling to only be done behind closed doors by willing practitioners, that should not limit the collective ability of those practitioners to contribute to important policy debates. In fact, quite the opposite. The models are powerful policy tools,

[99] Mitchell (2017) *Forget economic modelling, real world experience wins hand down,* SMH 26 Oct 2017, https://www.smh.com.au/business/forget-modelling-have-a-chat-with-a-cabbie-20171026-gz8o2d.html

and they can be improved greatly for modern policy debates, they should just never be used to deceive non-practitioners in those same policy debates.