Opportunities and Challenges for CGE Models in Analysing Taxation

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Taxation analysis seeks to describe the effects of current taxes, make forecasts, and assess proposed reform options. In each case, the effects on market outcomes, distribution of the tax burden, and distortions to decisions and economic efficiency are estimated. When second round effects are important, including for most taxes on business and where exemptions from comprehensive tax bases are significant, general equilibrium models are required. A computer general equilibrium model (CGE) with detailed and disaggregated industry, product and factor markets has great potential to quantify the general equilibrium effects of taxation. Challenges and areas for development of available CGE models for taxation analysis include: disaggregation of households to assess distribution effects and allow for different elasticities; modelling the effects of the hybrid tax treatment of different household saving and investment options; disaggregation of some business decisions to capture the effects of departures from comprehensive tax bases and of decision makers facing different tax systems; and, modelling and conveying the implications of imperfect knowledge of key assumptions and parameters.

JEL: C68, H20

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This is the author manuscript accepted for publication and has undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the [Version of Record](#). Please cite this article as [doi: 10.1111/1759-3441.12202](https://doi.org/10.1111/1759-3441.12202)

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Article type : Manuscript

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Abstract

Taxation analysis seeks to describe the effects of current taxes, make forecasts, and evaluate proposed reform options. Effects on market outcomes, distribution of the tax burden, and distortions to decisions and economic efficiency are estimated. When second-round effects are important, including for most taxes on business and where exemptions from comprehensive tax bases are significant, general equilibrium models are required. A computable general equilibrium (CGE) model with its detailed and disaggregated industry, product and factor markets has great potential to quantify the general equilibrium effects of taxation. Challenges and areas for development of available CGE models for taxation analysis include: disaggregation of households to assess distribution effects and allow for different elasticities; modelling the hybrid tax treatment of different household saving and investment options; disaggregation of some business decisions to capture departures from comprehensive tax bases and decision makers facing different tax systems; and, conveying the implications of imperfect knowledge of key assumptions and parameters.

1. Introduction

The commonwealth, state (and territory) and local governments in 2014-15 collected \$464.7 billion in taxation, or about 27 per cent of GDP (ABS, 2017). Taxation is the main way in which governments transfer limited labour, capital and natural resources from private use to fund the

¹ A previous version of this paper was presented as a keynote lecture at the 2017 National CGE Workshop hosted by the Centre of Policy Studies, Victoria University.

supply of public goods and services, and to achieve equity objectives via progressive taxation, direct provision of income, and provision of basic goods and services to all.

Estimating the effects of taxes on market outcomes, efficiency and redistribution is an important area of economic analysis and policy evaluation. This paper seeks to explain some of the opportunities for the use of computable general equilibrium (CGE) models for the analysis of Australian taxation, and to note some of the challenges in the design of value-adding CGE models. There are two general findings. First, there are large areas of complementarity with the use of a CGE model and other economic models, including the conventional partial equilibrium model which dominates public finance text books. Already there is an impressive history of the use of CGE models for the economic assessment of taxation in Australia, including evaluations of the ANTS taxation reform package of 2000 to use a GST to replace many existing indirect taxes and a partial increase of the consumption to income tax mix (including Dixon and Rimmer, 1999, and Murphy, 1999), and assessments in recent years of proposals to reduce the corporate income tax rate (including Cao et al., 2015, Murphy, 2016, and Dixon and Nassios, 2016). Second, as in other applications of CGE models, including assessments of reductions of tariffs, other microeconomic reforms, the introduction of a carbon tax, and detailed industry, product and factor effects of internal and external macroeconomic shocks, the specific CGE model will vary with different tax issues.

The paper is organised as follows. Section 2 provides a background of the reasons for, and the purposes of, economic analyses of taxation. The opportunities for, and additional insights provided by, a CGE model analysis relative to a partial equilibrium model are explored in Section 3. Section 4 suggests some areas for the development of available CGE models, and by way of illustration recent models used by Treasury (Cao et al., 2015), Murphy (2016a) and the COPS suite of models (Dixon and Nassios, 2016), to analyse contemporary tax reform options. A final section concludes.

2. Why Analyse Taxation?

We analyse taxation for three general sets of related purposes: to describe and understand the effects of current taxes; to forecast the future where taxes are important; and, to evaluate tax reform options.

2.1 Describe and understand the current system of taxation

A starting point describes what is taxed and how the tax is designed. For each tax this includes the tax unit, the tax base, and the tax rate schedule. The tax unit can be an individual or household, or a business enterprise. Tax bases or the taxable sum can be one of: income, and then capital income and labour income; expenditure in aggregate and categories of expenditure; wealth or assets; and, property transactions. Included in the tax base description is the set of special exemptions and deductions which result in the actual tax base being smaller than a comprehensive tax base. The tax rate schedule can be a flat rate meaning the average and marginal rates coincide, or a progressive rate schedule with both the average and marginal rates rising with the taxable sum, but a higher marginal than average rate.

To assess the first-round effects of taxation on decisions by households, businesses and others, one approach initially calculates an effective tax wedge. The tax wedge is the addition to marginal cost to the taxpayer imposed by the tax on the buyer or the seller of a taxed factor, good or service, asset, or other item. Relative to the pre-tax decision context, the tax wedge places a gap between the buyer tax-inclusive price and the seller after-tax price. The changed market prices stimulate decision changes by both buyers and sellers.

The effects on market outcomes of tax-induced decision changes by buyers and sellers involve several variables. These include, prices and quantities of inputs and outputs, after-tax costs, disposable incomes, outlays, and taxation revenues. A general equilibrium model can include changes also to macroeconomic aggregates, such as employment and wage income, GDP and GNI.

An important area of taxation analysis is the redistribution effects. Principle interest is the economic incidence, or who pays the tax once markets adjust. Ultimately, all taxes are paid by individuals, either as lower disposable incomes, lower asset prices, or as higher prices of purchased goods and services. For an open economy, a distinction can and should be made between residents and non-residents. Important in any distribution assessment is the characteristics of, and then the level of disaggregation of, households/individuals by one or more of income, age, wealth, gender, education, health and other socio-economic characteristics. In addition to a long run comparative static equilibrium effects, often the transition paths between the two equilibria are of interest. A more challenging distribution assessment includes changes over several decades or over the life-cycle as households and individuals transit across different categories of income, age and demographic characteristics over time.

Almost every form of taxation changes relative prices. Examples include taxation of time allocated to employment but not to leisure, different effective tax wedges on different saving and investment opportunities, and different tax systems and their different effective tax burdens on different goods and services, assets and other market transactions. For those pre-tax decisions starting at society efficient quantities, the tax induced relative price changes distort decision choices and result in a loss of efficiency. That is, in addition to a dollar for dollar transfer from taxpayer to the government, taxation involves an efficiency loss generally referred to as an excess burden. Where the initial market solution involves a market failure, for example an external cost, a taxation induced change in relative prices may work to correct the market failure and generate an efficiency gain.

While not considered further in this paper, taxation adds to the complexity of decision making, and it adds costs of government administration and taxpayer compliance costs.

2.2 Forecasting

Governments and many business investors seek estimates of the effects of taxation in the future. For governments, taxation is the key source of revenue in planning budget expenditures and the conduct of fiscal policy for better macroeconomic outcomes. The expected returns on many business investments are sensitive to taxation over an extended capital asset life cycle.

As is the case for economic forecasting in general, forecasting future taxation and its effects takes place in a world of imperfect information. Inevitably, all taxation forecasts are subject to error.

2.3 Analysing Tax Reform Options

Evaluating the effects of tax reform is likely to be top of the list of valuable applications of CGE models. Analysing tax reform follows the same principles and strategies well established in the CGE model literature assessments of the economic effects of changes in industry policy and changes in other exogenous factors.

Taxation reform can involve changes in tax bases, including removing or adding special exemptions and deductions, changes to tax rate schedules, and changes of the mix of taxes. Some potential taxation reform options for Australia can be found in the Henry Review (Henry, et al., 2010), the government's Re:Think (Australian Treasury, 2015), various state government reviews, and many others proposed by academics, and business, ACOSS, and other special interest organisations.

The structure of a comprehensive tax reform analysis involves the following steps. An initial or base case represents the current system of taxation as detailed in Section 2.1 above. Second, taxation reform options are specified as changes to tax bases and tax rates. Changes in tax bases and rates are modelled as changes in effective tax wedges and relative prices facing household and business decision makers. Third, the effects of decision responses to the changed effective tax rates on market prices, quantities, revenues and so forth are estimated for the policy reform scenario. Fourth, effects of the reform option or scenario are then evaluated relative to the base case scenario. The scenario comparison includes the effects of the tax reform proposal on: revenue; distribution of the tax burden, including lists of winners and losers; distortions to decisions, including changes to average and marginal excess burdens, and gains/losses of economic surpluses or utilities; and, changes to simplicity and operating costs.

3. Additional Contributions of CGE Models for Analysing Taxation

I see CGE models useful for the assessment of existing taxes and for evaluating tax reform options discussed in Section 2 above as a complement to, rather than as a substitute for, other modes of economic analysis.² By way of illustration, this section describes the contributions of, and the limitations of, the conventional partial equilibrium model used for analysing taxation which dominates most public finance text books, for example Gruber (2016) and Abelson (2012). At the same time, a partial equilibrium model provides important building blocks for a general equilibrium model analysis of taxation. The advantages of a CGE model include: the ability to capture multiple aspects of a general equilibrium; provide quantitative estimates of the effects of taxation; and assess effects for large numbers of categories of products, industries, factors of production and households with different characteristics, and even different layers of government. In addition, formulation of the CGE model focusses the mind to make assumptions explicit, and it allows exploring the sensitivity or robustness of the analysis to alternative assumptions and values for key uncertain parameters.

3.1 Illustrative Partial Equilibrium Model

Figure 1 provides a partial equilibrium model for the market for a taxable item. The tax base could be: a factor such as labour, capital, and then disaggregation into categories of labour and capital; a good or service, and categories of goods and services through to aggregate household consumption; an asset such as land and other measures of wealth; or, a transaction such as the sale of property. In the absence of taxation, market demand given by D and market supply given

² All economic models simplify a much more complicated real world. The challenge is to find a tractable representation of the key relationships and parameters driving the outcomes of interest.

by S determines the quantity traded, Q , at a price, P , for both the buyer and seller, with expenditure and receipts, QP .

Figure 1 Partial equilibrium model

Taxation may be levied in the first instance on the buyer, the seller, or both. For example, for labour, income tax is paid by the employee or supplier, and payroll tax is paid by the employer or buyer. In the case of shareholder investments in a company, there is a mixture of company tax paid by the company as buyer, and on the seller side personal and superannuation fund income taxes paid by the resident shareholder and withholding taxes levied on the non-resident shareholder. Tax as an additional cost can be represented as a downward shift of the D , an upward shift of S , or a combination. The taxes place a tax wedge, T , between the tax-inclusive price paid by the buyer, $P_{b''}$, and the after-tax price received by the seller, $P_{s''}$.

Key market effects of the tax in Figure 1 are: a reduction in quantity to Q'' ; a rise in market price to the buyer to $P_{b''}$; a fall in price for the seller to $P_{s''}$; and tax revenue of TQ'' . The more elastic either the demand or supply, the larger the quantity reduction. In the extreme, if either demand or supply is perfectly inelastic there is no quantity change, such as for a comprehensive base land tax. Economic distribution of the tax burden is independent of whether the statutory tax is imposed on the buyer or seller. The share of the tax burden depends on the relative elasticities of supply and demand, with the less elastic side bearing a larger share. Assuming no market

failures³ and efficiency of the before-tax quantity at Q , the efficiency cost of the tax caused decision change to reduce quantity to Q'' is given by the area abc . The efficiency cost per dollar of tax revenue of the tax-caused decision to reduce quantity can be represented as the average excess burden equal to $\text{area } abc / \text{tax revenue}$, or by the marginal excess burden given by $(d(\text{excess burden}) / dT) / (d(\text{tax revenue}) / dT)$. Both the average and marginal excess burdens increase with the tax rate and they are larger the more elastic supply and demand.

The illustrative analysis of Figure 1 readily can be generalised in several ways; and similarly for a CGE model. First, rather than the comparative static analysis, one can add lags in supply and demand adjustments via less elastic short run curves, and/or impose sticky prices, to trace a time path of adjustment. Second, the simplifying assumption of a flat rate tax can be generalised to allow assessment of the effects of a progressive rate schedule by disaggregating households and businesses into categories facing different marginal tax rates.

If the first-round effects of a tax described in Figure 1 are far larger than any second-round effects on decisions in other parts of the economy, a partial equilibrium analysis tells most of the story. However, when changes in prices and quantities of the market of the partial equilibrium model induce a second-round of changes of prices and quantities of markets for other factors, products and incomes, a general equilibrium analysis becomes necessary. Some example situations where second-round decision changes are important, and which provide opportunities for a CGE model for a more complete analysis, are considered next.

3.2 Significant Second-round Effects

Most of the taxes levied on business have significant second-round effects on other businesses and on households in addition to the first-round effects on those businesses who pay the statutory tax to government. In most cases, tax caused changes to decisions and prices at one step of the supply chain induce changes to other business decisions up and down the supply chain. Decision changes along the supply chain include changes to quantities and prices for labour, machinery and other inputs. Taxes on key business inputs, including payroll tax, land tax, fuel excise, motor vehicle taxes, conveyance duty on property transfers, and other stamp duties, as well as inducing changes in the taxed firm's input mix and product market price and quantity decisions flow through to change other decisions and outcomes along the supply chain, and ultimately the prices paid by and the incomes received by households. A CGE model employs a general equilibrium framework to collate the first- and second-round decision responses to taxes

³ In Section 3.2 below the example of market failures associated with external costs is discussed.

in estimating the net effects of the taxes initially paid by business on market outcomes, economic incidence of the taxes, and distortions to decisions and efficiency costs.

While corporations transfer corporate income tax to government, once markets adjust to the changed circumstances the tax is passed onto, and borne by, individuals. Individuals bear the economic incidence of taxes as lower returns to investors, lower payments for labour and other inputs, higher product prices, and likely some combination.

Business income tax reform options under consideration include alternative choices of the tax base. The current corporate income tax base includes the normal return plus economic rents earned on equity funds invested; with interest on debt funds a deduction. One set of alternative tax bases exempt the normal return and tax just the economic rent component. Economic rent base taxes include a cash flow and an allowance for corporate equity (ACE). Or, the normal return on debt funds as well as the normal return plus economic rent earned on equity funds would be taxed with a comprehensive business income (CBIT). A source base of the current corporate tax might be compared with a destination tax base. The current system of taxation of capital income earned by Australian companies differs between residents and non-residents, and then across different non-residents depending on tax treaty. The current company income tax system and the alternatives noted above impose different effective tax rates on many decision options, including aggregate investment and its composition, business organisation form, the debt versus equity finance mix, distribute versus retain income, and so forth. A general equilibrium model, including a CGE model, is required to assess the many second-round and general equilibrium effects of the different corporate tax bases and rates.

Assessment of the effects of the many special deductions and exemptions from comprehensive tax bases, and of reform options for larger or smaller tax bases, require disaggregation of industry and household decision choice options into categories with different effective tax rates. Current tax bases with important exemptions from a comprehensive base include payroll tax exemptions for small business and others, land tax exemptions for owner occupied property and land for primary production, and the GST exemptions for basic food, health, education, water and sewage. Taxation of the narrow base has important second-round effects on decisions in the exempt base, and then there are flow-through effects to factor suppliers and product buyers from the taxed and exempt subsets. While partial equilibrium models can capture some of these second-round effects, a CGE which disaggregates into the taxed and tax-exempt decisions provides a formal framework to capture the many decision changes, and then their net effects on product and factor market outcomes, distribution and efficiency.

A related set of examples deserving a general equilibrium analysis arises with the very different tax systems and different effective tax wedges on the capital income earned on different household saving and investment options. For example, capital income earned on investment in owner occupied housing faces no tax on imputed rent and capital gains, the nominal income return on financial deposits and dividends is taxed at the personal rate, earnings on funds invested in superannuation face a flat rate of 15 per cent (and 10 per cent on capital gains) during the accumulation phase and zero in the retirement phase (except for very large sums), and taxation of income earned on other property benefits from negative gearing and a half rate on realised capital gains.⁴ Changes in the effective tax on any one of the different household savings and investment options, including a reform for a level playing field, will have important second-round effects on decisions for the close substitute options.

Where taxes initially fall on capital income generated by assets, changes in the after-tax capital income will flow through to changes to asset prices. In a world of rational expectations and flexible markets, asset prices approximately equal the present value of the expected future stream of after-tax income flows.⁵ A higher (lower) capital income tax would become a one-off capital loss (gain). Portfolio model choices to determine the allocation of aggregate saving across the different investment options with their different effective tax rates would be an important component of a general equilibrium analysis, including for a CGE model.

An interesting example of important second-round effects of taxation concerns taxation of selected products or production methods to internalise external costs and the issue of a double dividend (Goulder, 1995). Examples include taxes on pollution, such as a carbon or emissions tax, excise on alcohol and tobacco, and proposals for special taxes on sugar and fat rich products. By internalising the external cost, a first dividend or efficiency gain correcting the externality is created. Concurrently, the special tax generates a windfall addition to government revenue. Some suggest this windfall is a second dividend, if the windfall is used to reduce other distorting taxes, e.g. income tax. But, most of the externality correction tax is passed forward as higher prices for the polluting products, e.g. higher electricity and transport prices with a carbon tax. The higher prices raise the cost of goods and services purchased by households. All else constant, including income and other taxes, the higher prices of the pollution intensive products

⁴ Henry et al. (2010) provide illustrative estimates of the wide range of different effective tax rates.

⁵ Formally, the asset price, A , is linked to the market annual rent return, R_t , and the tax rate on the rent income, Tr , with a discount rate, d , as $A = \sum R_t(1-Tr)/(1+d)^t$. Note also that the tax on rent income, Tr , is linked to a tax on the asset at rate Ta , with $Tr = Ta / (Ta + d)$ (Henry, et al., 2010, page 270).

reduce effective purchasing power per hour of employment.⁶ This additional cost of living effect of the external cost correction tax aggravates distortions caused by the existing taxes to work versus leisure decisions, and the higher cost of living has redistribution effects, and often regressive redistribution effects. Then, an approximate neutral redistribution package and one to minimise overall taxation distortions requires explicit recycling of the externality correction tax revenue windfall as lower income or GST taxes.

3.3 A context of several taxes

Many taxation questions are concerned with the combined effects of several taxes, and in some cases of all taxes. A larger and broader context evaluates the equity and efficiency effects of the combination of taxation and means tested social security payments.

For example, to assess taxation effects on labour market decisions, rather than a set of individual partial equilibrium models for each of income, GST and payroll tax, often the required assessment is the combined effects of these taxes. Because of significant differences in details of the tax base and the tax rate schedule for each of these taxes a general equilibrium analysis embracing the different taxes is required.

Or, what are the combined effects of current land tax, conveyance duty and capital income taxation on investment in property, rent and asset prices, taxation efficiency, and the distributions of effective disposable income? Then, in an approximate aggregate revenue reform package replacing the current taxes, what are the comparative effects of the replacement options of a comprehensive land base or property (land plus buildings) base, and then flat or progressive rate schedules?

In a world of structural budget deficits, an increase in aggregate taxation revenue is high on the list of reform options. Here, assessment of the comparative effects of increasing some but not other taxes, increasing all taxes, and other fiscal reform packages is required.

Many proposed tax reforms involve packages of tax mix changes. The 2000 package with the introduction of the GST to replace the wholesale sales tax, other indirect taxes and to fund a lower income tax, was the subject of CGE model analysis (Dixon and Rimmer, 1999, and Murphy, 1999). The Henry Review (Henry, et al., 2010) proposed many tax reforms with only a limited use of a CGE model to estimate average and marginal excess burdens of different current taxes. A

⁶ Formally, effective purchasing power for an hour of work at a constant nominal wage, W , income tax rate, T_y , and indirect tax rate, T_i , is equal to $W(1-T_y)/(1+T_i)$. The externality correction tax increases the indirect tax burden T_i , and by reducing the effective purchasing power per hour of work it aggravates distortions of the current T_y and T_i taxes on decisions to work versus untaxed leisure.

CGE model can be designed to incorporate the different effects of the current set of taxes as the base case for comparison with reform options involving changes to several tax bases and rate schedules.

3.4 Additional information

Relative to a partial equilibrium model, a CGE model provides data on key macroeconomic aggregates, such as GDP and GNI and their components, aggregate price indices and exchange rates, aggregate employment and investment. If utility functions are added to the model, as proposed in Section 4 below, more direct measures of household welfare gains and losses are generated.

3.5 Partial equilibrium to general equilibrium

There are many economic model types to extend the partial equilibrium model of tax analysis illustrated in Figure 1 to capture important second-round effects with a general equilibrium framework. Theoretical general equilibrium models provide a general framework. Simplicity and tractability restricts theoretical general equilibrium models of taxation to high levels of aggregation.

Then, empirical based models to capture some of the general equilibrium effects of taxation combined with large numbers of products, industries, factors of production and so forth can take many forms. One set of models are denoted as static microsimulation models. Examples include ABS studies of the incidence of taxes, social security payments and government expenditures on health and education by households classified by income, age, family structure and so forth (ABS, 2012), Treasury models of effective marginal and average tax rates drawing on details of income tax rate schedules and allowances and means testing of social security payments with the current model CAPITA (Stevensen, et al. 2017) and the preceding STINMOD and PRISMOMOD models. Microsimulation models capture the many details of different tax bases and progressive tax rate schedules which vary across households with different economic and demographic characteristics. Relative to CGE models, microsimulation models impose the link from statutory tax incidence to economic incidence, and often they assume a complete pass forward to households, and they assume no quantity decision changes by households and no changes in market prices and incomes. The Melbourne Institute with its MITTS model added some labour market behaviour response (Creedy, et al. 2003).

Available Australian CGE models, including those used by Treasury, Victoria University and Murphy, allow for general equilibrium model determination of prices for high degrees of

disaggregation of final goods and services, business input mixes, factors of production, international trade and macroeconomic outcomes determined by the decisions of businesses, households, government and international trade. Each model has a general framework and data base. In practice, each specific issue application of a CGE model expands the details of some parts of the economy, often different equilibrium or model closure assumptions are imposed, and sometimes input into or further analysis of the output of the CGE model from an outside model is incorporated into the analysis. The Victoria University models provide details of the dynamic time path of responses to shocks, including taxation changes, while current versions of the Treasury and Murphy models are comparative static models.

Another format of an empirical general equilibrium model builds on the overlapping generations framework. Tran and Wende (2017) is an Australian example application to taxation analysis. The overlapping generations model provides a way of assessing the effects of taxation over time for households, individuals and governments (and potentially businesses) as economic, demographic and other circumstances evolve over life cycles and careers. At this stage the available models have an aggregate story for industry and products relative to the high degree of disaggregation of industry, products and factors with available CGE models.

Although the foregoing paragraphs have emphasised different ways and models for a general equilibrium analysis of taxation, often the different models can be complementary. For example, theory provides the bases for constructing empirical models and for interpreting the results, and the empirical models provide additional information on magnitudes of effect and for higher levels of disaggregation of products, factors and so forth. Again, a microsimulation model can provide input on effective tax burdens for use by a CGE, and the outputs of a CGE can be used to incorporate behavioural responses in a microsimulation model.

4. Some Challenges to Further Develop CGE Models for the Analysis of Taxation

This section considers some areas for development of available Australian CGE models to enhance their value as a tool for the analysis of taxation. Clearly, the challenges and model development depend on the questions been asked, details and structure of the available CGE model, and the available resources. As has been the case for other application of CGE models, the answer will not be an omnibus model for all tax analysis, but rather suggestions for model developments peculiar to the question of interest.

4.1 Modelling Households

Expanding current CGE models with a single representative household to include a set of households with different characteristics is required (a) to evaluate vertical and horizontal redistribution effects⁷, and (b) to allow for differences in key parameters across different households.

Because the vertical and horizontal distribution effects of taxes across a heterogeneous population is critical to any discussion of taxation, models need to include a range of different households. The final incidence of all taxes falls on individuals or households as a combination of lower disposable income, lower wealth and higher prices. In the open Australian economy, a significant share of Australian source base taxes is borne by non-resident investors and consumers rather than residents of principal interest. There are many potential characteristics by which to categorise resident households, and then the number of household types in each category is another choice option. A common strategy to assess vertical equity effects, and one important in political debates, classifies households by income or by wealth, often by quintile or decile. Other characteristics to recognise the heterogeneity of households include generation and age, and household demographic structure. Rather than use output type characteristics such as income, an alternative classification uses measures of different household endowments such as education, health, carer responsibilities and work experience as drivers of labour incomes, and endowed asset stocks as drivers of capital income.

Where taxation significantly changes relative prices, disaggregation of households by different preferences which drive different decisions on expenditures and factor supplies can be important. For example, the household distribution effects of changes in the consumption base to income base mix of taxation varies with the average propensity to consume. Studies of taxes which change the relative prices of consumer goods and services, such as market failure correction taxes, likely require household disaggregation by expenditure patterns. For labour market decisions, generally it is accepted that compensated and uncompensated labour supply elasticities are much larger for females with carer responsibilities, those young and those approaching retirement, relative to mid-career high income males and females. Different categories of households may have different saving elasticities and portfolio preferences which affect aggregate saving and then its allocation between own homes, shares, superannuation and other assets. Assessment of tax reform packages which alter the relative effective tax burdens on the different types of capital income would benefit with the categorisation of households with different preferences.

⁷ Alternatively, as suggested by a reviewer, an interplay of changes in prices and incomes from the CGE model as inputs to a microsimulation model, such as the Treasury CAPITA model, could be used (Dixon et al., 1996).

An important set of household definition and description options is whether to represent household resource endowments, incomes and expenditure as (a) what might be termed the static snapshot picture, (b) a long term average, or (c) the time path of transitions across different states as defined by characteristics over time. For example, the ABS snapshot picture of household disposable income and expenditure reports an average propensity to consume for the bottom two quintiles larger than unity, and a very low average propensity to consume for those in the top two quintiles (ABS, 2011). Over several years many with a recorded high average propensity to consume experience higher incomes and those with a low average propensity to consume experience lower incomes. Together, a far narrower range of average propensities to consume is shown over several years or over the life cycle. Longitude data from the HILDA survey shows that the income of many individual households jumps across deciles from year to year, including jumping in and out of poverty (Wilkins, 2016). Then, for example, a similar vertical equity and aggregate revenue reform package of a larger GST and lower income tax mix change would require a much larger income tax rate reduction for those on lower incomes for the static snapshot picture than for a long term average.

The strategy of Ballard et al. (1985), Murphy (2015, 2016), Treasury (Cao, et al., 2015) and others to formally model each household category as maximising a utility function which allows for work (and market goods and services) versus leisure (and home produced goods and services) trade-offs, and for intertemporal consumption trade-offs, provides an explicit model for assessing the efficiency and distribution effects of taxes which induce changes to employment and saving decisions. Measures of efficiency and redistribution effects would be assessed as changes in compensating variation (CV) or equivalent variation (EV). A common strategy involves specifying a CES utility function and calibrate function parameters to be consistent with available econometric literature estimates of labour and saving supply elasticities. This utility function strategy has clear advantages over such measures as aggregate or per capita GDP and consumption, including that the utility measures place a value on leisure, allow for consumption smoothing over time, and they distinguish effects on residents and non-residents.

4.2 Modelling changes in tax bases

Many of the existing tax bases are less than comprehensive with special exemptions and deductions, and some tax reform proposals are for broader tax bases. Examples include payroll tax, land tax and the GST. To assess the effects of the current taxes with their special exemptions and deductions, and then reform options involving a change to a comprehensive tax base, would

require replacing the typical firm by industry or the typical household with disaggregation by taxed and non-taxed base.

To illustrate, consider the current payroll tax and reform options. The current base exempts small business accounting for about a half of aggregate employment, but with varying shares across different industries and across the states. A useful CGE model would disaggregate the usual formulation of a typical firm per industry into a typical small firm exempt from payroll tax and a typical large firm subject to payroll tax, and add functions and decisions for the interaction of decisions of both business sizes. Dixon et al. (2004) provide an excellent example. Interesting general equilibrium effects of the small firm exemption from payroll tax are the magnitudes of effects on the mix of small and large businesses, relative product prices, employment and wages. Other effects of interest include the mixes of employment and wages by occupation, skill level and industry, the distribution of household incomes, and efficiency costs of distortions to the mix of firms by size. An approximate aggregate revenue neutral reform package would have a broader base and a lower rate.

Another example has different sets of decision makers producing a similar product or purchasing an input, but each set faces different tax systems and effective tax rates. Current policy to lower the corporate tax rate, and initially for small business defined by annual turnover, provides a more specific example requiring disaggregation of firms by different tax treatment.⁸ Family owned small corporations face a different tax system and a different elasticity of supply of funds relative to multinational corporations and other large public listed companies (Freebairn, 2017). For resident shareholders, the imputation system largely offsets changes in corporate income tax. Then, tax base concessions and a lower corporate income tax rate lead to very small reductions in the effective tax rate for resident shareholders and for companies where residents are the only or dominant shareholders. By comparison, for non-resident shareholders the interaction of the corporate income tax system and the system of withholding taxes results in most of a deduction from a comprehensive base and a lower corporate income tax rate also becomes a lower effective tax rate. Large companies, and especially multinationals, with a significant share of non-resident shareholders have access to a large global capital market for funds, and hence a high supply elasticity. By contrast, the funds supply elasticity is relatively low for small family-owned companies.

⁸ There also are quite different special exemptions and deductions from a comprehensive business tax base which warrant other forms of business disaggregation by industry and size described in the Treasury Tax Expenditure document (Australian Treasury, 2016).

Assessment of tax reform options to broaden the GST base and/or to change rates is readily modelled with current CGE models given their detailed disaggregation of goods and services produced, consumed and subject to international trade. However, as noted in Section 4.1 above, to obtain information on the distribution effects will require replacing the typical household with a range of households. Also, choice of the base case assumption for the ratio of consumption to income for each household category will influence the design of the tax reform package and its comparative effects.

4.3 Household capital income and wealth

A high priority area for analysis of income taxation and of reform proposals requiring a general equilibrium model is the taxation of capital income earned on savings. The current system is a hybrid of different tax systems with very different effective tax rates across income earned on savings invested in the owner-occupied home, other property, unincorporated business, shares, superannuation and financial deposits (Henry, et al., 2010).

The capital income received for each of the household saving options have different characteristics, such as expected return, variability of return, liquidity, and the level of personal control and involvement. Different households have different portfolio preferences. Together, the different characteristics and portfolio preferences mean the different forms of saving are imperfect substitutes. An appropriate model to assess the effects on market outcomes, redistribution, efficiency and other effects of the current array of different effective tax rates on different saving options would include a household portfolio allocation model to represent the imperfect substitutability of the different saving options (and illustrated in Dixon, et al., 2015, and Harris et al., 2017) and the different effective tax rates.

Business borrowers of funds for investment face different effective tax rates on the different fund options. And, they have portfolio preferences which mean debt, equity, retained profits and other sources of investment are imperfect substitutes.

4.4 Modelling the taxation of decisions involving external costs

An interesting potential application of a CGE model would include a general equilibrium assessment of special taxes to correct market failures. Current examples include: taxes on tobacco, alcohol and gambling to internalise external costs; and, fuel excise and road user fees for motor vehicles as a crude form of user pays fee for government provided road services. Then, as with partial equilibrium studies, a complete CGE model analysis of the net efficiency

and redistribution effects of market failure correction taxes should include effects of the special tax on market decisions and outcomes of the taxed activities, plus the gains in less external costs and better pricing of services. In some cases, such as alcohol and gambling, it may be necessary also to disaggregate consumers into categories for different relative magnitudes of external costs per unit consumption, and perhaps also by different demand elasticities. If wellbeing is measured via utility functions using CV or EV measures, the costs of the externalities and the benefits of tax-funded services provided should be added to the utility functions.

4.5 Model Closure

Taxation brings some additional considerations to the usual CGE model closure assumptions for factor, product and other markets.

As is the case with studies of tariffs, long run market equilibrium closure for markets for goods and services and factors of production would equate quantities bought and sold, with the tax-inclusive price paid by the buyer and the after-tax return received by the seller determined endogenously. For some short run simulations, sticky prices may be imposed.

An important model closure assumption concerns the government budget when a tax reform changes the revenue generated. Budget closure options include: an endogenous budget outcome; a "balanced budget" with a lump sum offset to household income, and then with options of the distribution of the lump sum transfer across different households; off-setting change of another tax, and then which tax(es); and, off-setting changes of government expenditure, and then many options on the structure of the expenditure changes. In general, the different options will have different macroeconomic second-round effects. With Australia as an open economy where different taxes often have different effects on relative prices of traded and non-traded factors and products, the budget closure option also can have important effects on the taxation incidence between residents and non-residents, and for residents, different effects for those with different forms and magnitudes of exposure to international trade.

4.6 Uncertainty

All quantitative estimates of the effects of taxes on market outcomes, redistribution and efficiency are sensitive to model values for key parameters, such as the elasticities of the supply of and demand for labour and capital, profit shifting elasticities, and portfolio choices elasticities. The CGE studies of the effects of a lower corporate income tax by Cao et al. (2015), Dixon and Nassios (2016) and Murphy (2016) illustrate the sensitivity of effects of taxation to different values for some of the key investment parameters; and, sensitivity of results with a comparative

static assessment relative to estimates of an extended time path of adjustment to tax changes. For most key parameters, a wide range of estimated values, including confidence intervals, associated with different underlying model specifications, data and estimation methodology are reported in the literature.

A major challenge for analysts of taxation, including those using a CGE model, is how to represent and explain the extent of, and the effects of, imperfect knowledge about key parameters. Some options include: running scenarios with different parameter values; evaluate the robustness of estimated effects to alternative plausible parameter values; and, conduct monte carlo studies to derive probability distributions for estimated effects. There seems no easy answer, especially when the political and public debate prefers simple, probability one answers.

One explanation strategy employs a simplified version of the CGE model which includes only the dominant causal forces and parameters, a “back-of-the-envelope” model, to illustrate the key results in terms of directions and magnitudes of effects, and sensitivity to key parameters.

5. Conclusions

A CGE model is a powerful tool to analyse current taxes and reform options, and especially where a general equilibrium assessment to incorporate important second-round effects not easily captured in a partial equilibrium model is required. Important second-round effects arise with most taxes of business income and business inputs, where special exemptions and deductions from a comprehensive tax base are large relative to a comprehensive base, external cost correction taxes, and where interest is the combined effects of several taxes, each with different bases and/or rate schedules. Effects of taxation on macroeconomic outcomes also are obtained.

At the same time, complementarity of partial equilibrium and general equilibrium models, including a CGE model, is important. The partial equilibrium characterisation of the effective tax wedges and first-round decisions affected by the different taxes are building blocks for the CGE model. Where second-round effects are not easily included in a partial equilibrium model and they are large relative to the first-round effects, a CGE model can capture and quantify the second-round effects. High levels of industry, product and factor disaggregation in available CGE models, and other forms of disaggregation, provide details not feasible with simpler partial equilibrium and theory general equilibrium models. A partial equilibrium model, or “back-of-the-

envelope” model, may provide an intuitive story behind the detailed CGE model estimates of the market outcomes, redistribution and efficiency effects of taxation.

There are many directions for further development of available Australian CGE models for taxation analysis to enhance their usefulness. Assessment of redistribution effects requires replacing the current representative household with categories of households, and then with options of categorisation by, for example, income or assets, factor endowments, and by key elasticities influencing labour supply and saving decisions. Disaggregation of household saving and investment options with different effective tax wedges together with portfolio choice models is one strategy to better understand the effects of taxation on aggregate household saving and its allocation between owner occupied homes, other property, small business, shares, financial deposits and superannuation.

For some studies of taxation of business, further disaggregation of the current representative firm by industry and product may be required. Examples include disaggregation to assess the effects of significant exemptions and deductions from a comprehensive tax, such as payroll tax, and where different decision makers face different tax systems and effective tax rates, such as resident and non-resident shareholders.

Other areas of development of current available CGE models for taxation analysis include the inclusion of spill-over and direct effects of decisions involving external costs and benefits. Perhaps disaggregation of households and businesses with different magnitudes of the externalities and response elasticities also is desirable.

CGE models raise additional model closure questions and options, and particularly the government budget.

It is unlikely that there should be, or will be, a single and very large CGE model for the analysis of all taxation questions. Rather, as has been the case for CGE model analyses of other issues such as international trade and industry policy, in the context of a general taxation model framework, a made-for purpose specific CGE model with additional details relevant to each particular set of tax questions and economy circumstances will be developed.

While all economic models of taxation confront the reality of uncertainty about key parameters which significantly affect estimates of the magnitudes of effects of taxes and reform options, and sometimes the direction of effect, the greater number of key uncertain parameters and complexity of a CGE relative to a partial equilibrium model increases concerns about robustness

of reported results. There seems no easy answer to how to convey the implications of imperfect knowledge about key model assumptions and parameters to readers and policy makers.

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Title:

Opportunities and Challenges for CGE Models in Analysing Taxation

Date:

2018-03-01

Citation:

Freebairn, J. (2018). Opportunities and Challenges for CGE Models in Analysing Taxation. ECONOMIC PAPERS, 37 (1), pp.17-29. <https://doi.org/10.1111/1759-3441.12202>.

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