Inefficient at Any Level: A Comparative Efficiency Argument for Complete Elimination of Property Transfer Duties and Insurance Taxes

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Jason Nassios
And
James Giesecke
Centre of Policy Studies,
Victoria University

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Address: Centre of Policy Studies, Victoria University, PO Box 14428, Melbourne, Victoria, 8001
home page: www.vu.edu.au/CoPS/ email: copsinfo@vu.edu.au Telephone +61 3 9919 1877

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Inefficient at any level: A comparative efficiency argument for complete elimination of property transfer duties and insurance taxes

Jason Nassios[1], James Giesecke[2]

Centre of Policy Studies

Victoria University

Abstract

Harberger (1962) coined the term excess burden to emphasise that taxes impose costs in addition to the revenue they collect. Reviews of Australia's tax system have used point estimates of the excess burden for a series of Australian taxes, among other measures, to motivate and prioritise the nation's reform agenda. In this paper we commence the work needed to elucidate what the optimal tax mix in Australia might look like under alternative revenue raising efforts, by studying how the excess burden of four Australian taxes change as we alter their tax-specific revenue-to-GDP ratios. This is achieved via simulation with a large-scale CGE model with high levels of tax-specific detail. We show that property transfer duties and insurance taxes are highly inefficient even at low levels, strengthening the case for their complete replacement with more efficient taxes.

JEL Codes: C68; E62; H2; H71; R38

Keywords: CGE modelling; Immovable property tax; Recurrent property tax; Insurance tax; Value added tax; Personal income tax; Excess burden

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[1] Associate Professor, Centre of Policy Studies (Victoria University) and corresponding author. Email: Jason.Nassios@vu.edu.au

[2] Director and Professor, Centre of Policy Studies (Victoria University).

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1. Introduction

Australia's Future Tax System Review [Henry *et al.* (2010)], commissioned in 2008 and published in 2010, set out 138 specific tax reform recommendations. At a high level, these emphasised concentration of revenue-raising across a series of efficient tax bases (personal income, business income, private consumption and economic rents), and the removal of other taxes that do not fall under these categories. Most of the taxes currently relied upon by Australia's states and territories as funding sources do not fall under either of the four efficient tax bases listed by Henry *et al.* (2010).

Previous studies of the relative efficiency costs of Australia's taxes have calculated point estimates of the marginal excess burden for each tax, i.e., marginal excess burden estimated at the tax's current revenue raising effort [Cao *et al.* (2015); Nassios *et al.* (2019a,b)] . However, comprehensive tax reform, and/or large changes in the overall revenue raising effort of the state and federal tax systems, could involve large changes in tax rates for particular taxes. To understand what a comprehensively efficient tax system might look like, and to understand which taxes should best take up additional revenue raising load as inefficient taxes are cut, we require estimates of marginal excess burden for each tax across wide potential revenue raising loads, not just point estimates. This would allow us to answer questions like: What is the systemically-efficient distribution of revenue raising effort across all tax types? Should some inefficient taxes be retained, but at much lower rates?

Both these questions require an understanding of how the excess burden, or welfare cost for a given tax, vary as tax rates/thresholds vary. However, Australia's tax system is complex: Henry *et al.* (2010) for example identified 125 distinct taxes levied across all levels of government in Australia. While deriving welfare cost curves for each of these 125 taxes is beyond the scope of this paper, we illustrate how tax-specific relationships between marginal excess burden and revenue raising effort can be derived using a bottom-up, multi-regional model of Australia's state and territory economies. Our focus is on four taxes in particular: (1) Personal income tax (PIT); (2) The Goods and Services Tax (GST); (3) Property transfer duties (TDs); and (4) Insurance duties (IDs). There are three reasons for studying these four tax instruments. First, personal income tax and the GST are broad-based, efficient taxes, which are often advanced as candidates for replacing narrow-based, inefficient state taxes [Henry *et al.* (2010)]. Point estimates of the marginal excess burden for these two taxes are typically in the range of 20c – 30c per dollar of revenue raised. Second, property transfer duties and insurance duties are often identified as good candidates for reform [Freebairn (2017; 2020a, b)]. They are narrow-based and point estimates of their excess burdens are typically high. Third, a popular reform proposal is for the federal government to assist the states in reducing their reliance on inefficient tax bases. One possibility would be to raise the personal income tax and/or the legislated GST rate, and increase grant payments to the states and territories to fund removal of inefficient state taxes.

For each of the four taxes, we study how its welfare cost, or marginal excess burden, changes as its tax rate varies. The model and process we use to derive these tax-specific marginal excess burden distribution functions is described in section 2. In section 3, we study the marginal excess burden distribution functions for the personal income tax, GST, property transfer duties and insurance duties. Using OLS, we fit polynomial functions to these curves; these functions enable readers to readily estimate the welfare cost (benefit) of increases (decreases) in tax-specific revenues, under an assumption of revenue neutrality. We use the curves to estimate the welfare gain from funding the elimination of two high-cost state taxes using two low-cost federal taxes. In section 4, we present concluding remarks.

2. Model and method

2.1. Model

The Victoria University Regional Model with Tax detail (VURMTAX) is an extension of the VURM computable general equilibrium (CGE) model described in Adams *et al.* (2015), carrying detailed modelling of local, state and federal taxes that distinguishes it from VURM. Herein, we use a two-region (NSW and the Rest of Australia), 86-industry aggregation of the core VURMTAX database. Investment in each regional industry is assumed to be positively related to expected rates of return on capital in each regional industry. VURMTAX recognises two investor classes: local investors (i.e. domestic households and government) and foreign investors. Effective tax rates on each investor class differ, with foreign investors not liable to pay Australian personal income tax on their capital income, while they are also unable to claim back Australian franking credits. Capital creators assemble, in a cost-minimizing manner, units of industry-specific capital for each regional industry. Each region has a single representative household and a state government. The federal government operates in each region. The foreign sector is described by export demand curves for the products of each region, and by supply curves for international imports to each region. Supply and demand for each regionally produced commodity is the outcome of optimising behaviour. Regional industries are assumed to use intermediate inputs, labour, capital and land in a cost-minimising way, while operating in competitive markets. Region-specific representative households purchase utility-maximising bundles of goods, subject to given prices and disposable income. Regions are linked via interregional trade, interregional migration and capital movements, and governments operate within a fiscal federal framework.

VURMTAX provides results for economic variables on a year-on-year basis. The results for a particular year are used to update the database for the commencement of the next year. More specifically, the model contains a series of equations that connect capital stocks to past-year capital stocks and net investment; see Dixon and Rimmer (2002). Similarly, debt is linked to past and present borrowing/saving, and the regional population is related to natural growth and international and interstate migration. The model is solved with the GEMPACK economic modelling software [Horridge *et al.* (2018)].

In sections 2.2 – 2.5, we briefly describe how each of the four taxes we study herein are modelled in VURMTAX. The marginal excess burden is then defined in section 2.6, where we also outline the process used to derive tax-specific marginal excess burden distribution functions.

2.2. Personal income tax (PIT)

While traditional CGE models distinguish federal taxes as indirect taxes and tariffs, or factor income taxes, e.g., capital taxes or labour taxes, VURMTAX models personal income tax (PIT) as a direct tax on labour, capital and land income that accrues to local residents. While we recognise that Australia's personal income tax system is progressive, in this paper we take VURMTAX's assumption of a representative household and model the personal income tax as a flat-rate tax on taxable household income. We do not capture impacts such as heterogeneous labour supply responses, e.g., due to differing labour supply elasticities across the income spectrum and by gender, interactions with the personal benefits system, or the progressive nature of the income tax rate scale. The marginal excess burden we derive herein is best described as a personal income levy, where the effective rate on all labour, capital and land income rises in a homogeneous way.

In section 2.2.1, we outline the tax base and means by which franking credits are accounted for in our modelling, before summarising the data, equation system and assumptions used to model Australia's personal income tax system in VURMTAX.

2.2.1. Modelling Australia's franking credit system

Australia's franking credit system was implemented in July 1987 to avoid double taxation of company profits paid out as dividends to Australian-resident investors in Australian-listed companies [Peirson *et al.* (2009)]. When resident shareholders receive a franked dividend from an Australian company, they are provided a tax credit by this company in addition to the dollar value of the dividend they receive. This credit reflects the fact that the company has already paid tax (at the company tax rate) on the profits from which the dividend has been paid, i.e., the dividend is paid out of post-Australian-company-tax profits. In receiving a fully-franked dividend, capital income received by Australian residents is effectively taxed at the personal income tax rate.

As discussed by Dixon and Nassios (2018a), dividend imputation systems are rare internationally: Australia, New Zealand, Chile and Mexico are the only OECD countries to operate a dividend imputation system. To model this system, we follow the approach in Dixon and Nassios (2018a), where capital ownership is distinguished along two dimensions:

1. By investor type: The domestic capital stock is either foreign-owned or locally-owned, with the industry-*i* and region-*q* capital stock's foreign ownership share defined as FORSHR(*i*,*q*). Income from locally-owned capital accrues to households. Where that capital is not personal income tax exempt, e.g., as is the case for owner-occupied dwellings, the income is subject to personal income tax.
2. By income type: Capital income is either franked or unfranked, with the share of franked dividends received by capital owner type $o \in \{Loc, Fgn\}$ defined as FSHARE(*o*). While FSHARE(*Fgn*) is non-zero (because foreign investors do own some shares that pay franked dividends), they are not permitted to claim back those franking credits in VURMTAX. This is accounted for via the parameter FCLAIM(*o*), which is zero for foreign investors. FCLAIM(*Loc*) and FSHARE(*o*) are then calibrated such that the ratio of franked dividends claimed by households relative to aggregate company tax collected is equal to 33 per cent, matching the average claim ratio in Australian Taxation Office statistics for over 2010-11 to 2013-14.

To permit franking credits attached to franked dividends paid by companies to local capital owners to be claimed by those owners, we apply the framework developed in Dixon and Nassios (2018a). This yields the following expression for personal income tax collections (PITTAX) in VURMTAX, in terms of the flat-rate personal income tax rate T_PIT:

$$\mathrm{PITTAX} = \mathrm{T\_PIT} \cdot \mathrm{PITBASE} - \mathrm{PI} \cdot \mathrm{FCRED}, \tag{1}$$

with the personal income tax base defined as PITBASE taking the following form:

$$\mathrm{PITBASE} = \mathrm{DEDPIT} \cdot \left(\mathrm{LABINC} + \mathrm{NOT\_RET} \cdot \mathrm{CAPINC} \cdot \left[1 - \mathrm{T\_CAP} \cdot \mathrm{DEDCIT}\right] + \mathrm{PI} \cdot \mathrm{FCRED}\right), \tag{2}$$

where FCRED is the aggregate dollar-value of franking credits claimed by households in their tax returns, defined as:

$$\mathrm{FCRED} = \mathrm{FCLAIM} \cdot \mathrm{FSHARE} \cdot \mathrm{T\_CAP} \cdot \mathrm{DEDCIT} \cdot \mathrm{CAPINC}, \tag{3}$$

and:

LABINC is labour income earned by households.

CAPINC is personal income tax liable capital income earned by households. This includes, for example, income earned from rented low- and high-density housing, but excludes imputed owner-occupied housing rents. The public sector is also assumed to be personal income tax exempt.

T_CAP is the effective tax rate on corporate income in Australia, i.e., the legal rate less allowable deductions;

PI is the degree to which franking credits paid to households can be claimed back to offset personal income tax liabilities. This variable takes the default value of 1.

DEDPIT is the impact of tax-free thresholds and tax deductions on the personal income tax base, calibrated to ensure the average tax rate T_PIT in the base-year (2016/17) equals the Australian average personal income tax rate set out in the Parliamentary Budget Office (2017) report of 23.9 per cent. This yields a value for DEDPIT of 82.7 per cent. Over the baseline forecast, we align T_PIT to forecasts provided by the Parliamentary Budget Office (2022) to 2033, with annual increases in T_PIT thereafter calibrated to match the average annual rate implied in the 2022 – 2033 forecast by Parliamentary Budget Office (2022).

DEDCIT is the impact of interest expense deductibility on Australia's corporate income tax base. We calibrate the share of interest expense deductions claimed by industries in VURMTAX to the share Australian corporates claimed in ATO Taxation statistics, relative to corporate earnings before interest and tax (EBIT). This reduces the corporate income tax base in VURMTAX, relative to a base equal to aggregate capital income, by 36.6 per cent. Reflecting this, we set the value of DEDCIT to 0.634, which yields an economy-wide average company tax rate of 18.2 per cent that is of similar order to the US Congressional Budget Office (2017) estimate for Australia of 17.0 per cent.

NOT_RET is the impact of retained corporate profits, which reduces personal income tax liabilities on corporate income earned by households. In VURMTAX, the share of retained profit is set to 20 per cent by setting NOT_RET equal to 0.8, which yields a payout ratio of 80 per cent that is similar to the economy-wide payout ratio in Australia in 2015 [Bergmann (2016)].

In this framework, pre-tax rates of return on capital in Australia are industry- and region-specific, but do not differ across capital owners, i.e., foreign investors and local investors own the same type of industry- and region-specific capital. Post-tax rates of return differ however: for local investors, the tax rate on capital income is set by the average personal income tax rate, after allowances are made for allowable deductions such as interest payments, and retained earnings (which are not taxed at the personal income tax rate herein). Foreign investors generally pay the corporate tax rate, less allowances for deductions and double taxation treaty concessions.

Together with VURMTAX's labour supply specification that follows the labour / leisure choice mechanism outlined in Giesecke *et al.* (2021), the equation system herein provides sufficient detail to study the impact of: (i) adjustment in the average rate of personal income tax in Australia, e.g., a proportional change in all marginal tax rates; (ii) changes in corporate interest deductibility; (iii) changes in foreign taxation treaty agreements; (iv) long-run trends in dividend payout ratios; and (v) partial (or complete) scale back in Australia's dividend imputation system, e.g., see Dixon and Nassios (2018b). The marginal excess burdens derived herein are effectively personal income levies; see point (i) above.

2.3. The Goods and Services Tax (GST)

Following Giesecke and Tran (2018) and Giesecke *et al.* (2021), our detailed VURMTAX GST model recognises: differentiated legislated tax rates across commodities; differentiated legislated GST exemption statuses across commodities; differentiated legislated capacities to reclaim GST paid on inputs to production and investment; differentiated rates of registration for GST purposes across industries; effective taxation of exports via application of GST on domestic purchases by non-residents; and, the potential for incomplete GST collections due to non-compliance. Because the GST model is embedded within the multi-regional framework of VURMTAX, it must also describe details of the legislated GST system as it relates to all commodities, from all sources, used by all agents in all regions. Consistent with the structure of VURMTAX, the agents in the GST theory comprise industries, capital creators, and final demanders. The regions comprise the eight states and territories. The sources comprise the eight domestic regions plus imports. For full details and a description of the equation system, see Giesecke and Tran (2018).

2.4. Insurance duties (IDs)

VURMTAX recognises five distinct levies/duties on contracts of insurance:

1. *General insurance duties.* The tax base is the insurance premium paid for each contract issued, and the tax rate is ad valorem. Life and health insurance contracts are general insurance duty exempt, while duties on compulsory third party insurance are carved out from general insurance duties and modelled distinctly (see below). General insurance duties are GST exempt, and hence fall outside the GST tax base.

2. *Life insurance levies.* The tax base is defined as the life insurance benefit payable per contract raised, and the tax rate is ad valorem. This differs from the approach for general insurance, where the tax base is the premium paid.

3. *The health insurance levy.* Most Australian jurisdictions treat health insurance as duty-exempt. However, in some states, e.g., NSW, a specific tax is levied as a fixed charge per customer, paid by any organisation that provides health insurance benefits.

4. *The Emergency Service Levy (ESL).* Two Australian states collect a levy on certain types of insurance contracts, in addition to the duties collected from general, life and health insurance. Notionally, this ESL is used to partially fund emergency service provision. The tax base is the insurance premium paid on various types of general property insurance, and the levy is GST-liable.

5. *Compulsory third party (CTP) insurance duties:* CTP motor vehicle insurance is mandatory in Australia, with premiums used to cover liabilities of all drivers for injury caused to passengers and other road users in an at-fault motor vehicle accident. While CTP insurance is compulsory, duties are also collected on CTP insurance premiums. Throughout Australia, CTP premiums and insurance duties are typically paid by road users with their annual motor vehicle registration charges. The duties are essentially lump sum taxes charged per vehicle. The resulting distortions to decision making are therefore similar to those caused by motor vehicle registration and weight taxes; see Nassios *et al.* (2019a) for a detailed description. Herein, we model CTP insurance duties as production taxes, largely collected from the private transport industry. In VURMTAX, the private transport industry uses inputs of capital [motor vehicles], motor vehicle repair services, fuel, and some motor vehicle parts, and sells its output (private transport service) exclusively to households. Some CTP tax load is also borne by industries intensive in road transport service delivery, i.e., it is levied upon trucks used by the road freight industry, and other industries maintaining commercial vehicle fleets.

To accommodate this diversity of insurance taxes, we model the demand for insurance in identical fashion to Nassios and Giesecke (2022). To summarise, we account for three types of insurance commodity, produced by a single insurance industry operating in each region. These three commodities are (i) health insurance; (ii) life insurance; and (iii) general insurance. Each commodity is differentiated by its sales structure, price elasticity of demand, and any incident duties/taxes. In calibrating VURMTAX, significant effort was made to ensure sales tax rates reflect APRA Quarterly Performance Statistics for General, Life and Health Insurers, and that price elasticities of demand conform to academic assessments of insurance demand elasticities.[3] For a full discussion of this parameterisation, we refer the reader to Nassios *et al.* (2019a).

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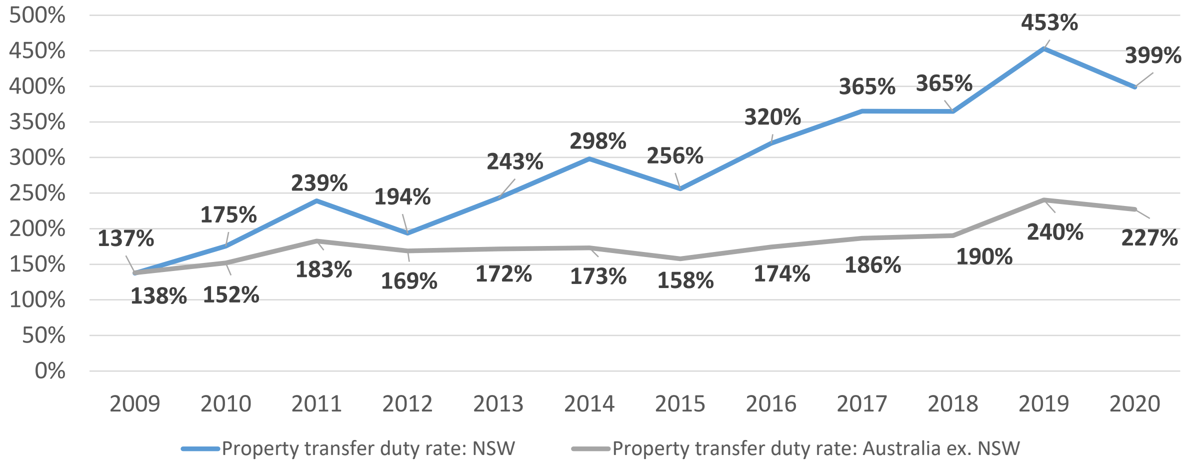
[3] In order to set the elasticity of demand for insurance, we reviewed a survey by Hao *et al.* (2018). For Health insurance, the household expenditure elasticity in VURMTAX is calibrated to yield a price of demand equal to

2.5. Property transfer duties (TDs)

Stamp duty on property conveyancing applies to the transfer of ownership of most properties, with the duty base being the value of the property purchased. In all Australian states, a progressive rate schedule is employed. While the tax base for conveyancing duty is the value of the property, the economic incidence falls on the process of property transfer. The value of the resources used in transferring property ownership is usually only a fraction of the property price. This is highlighted in Figure 1, which plots ABS cat. no. 5220 data on ownership transfer costs (before taxes) relative to property transfer duty collections from ABS cat. no. 5506 in NSW and the rest of Australia. The sharp rise in conveyancing duty rates in NSW relative to the RoA depicted in Figure 1 is reflective of the sharp rise in NSW property prices, relative to the price of the goods households and industries consume to transfer their properties.

Figure 1: Ad valorem equivalent of transfer duty taxes on ownership transfer costs in NSW and the rest of Australia (RoA).



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the mid-point of the range outlined by Butler (1999) for the Australian health insurance market. For life insurance, we use a similar approach and rely on estimates of the price elasticity of demand for term life insurance by Viswanathan *et al.* (2006). For emergency service levy liable general insurance, e.g., house and contents insurance for households, we calibrate the price elasticity of demand in VURMTAX using the elasticity with respect to (w.r.t) tax of -1.34 estimated by Tooth (2015) for Australia. In order to convert the elasticity w.r.t tax to a price elasticity of demand, we first calculate the pre- and post-tax loading for Type A general insurance in NSW using the approach in Nassios *et al.* (2019a). On a pre-tax basis, the loading is equal to 1 / 0.586 – 1 = 70.65%, i.e., the pre-tax cost of Type A general insurance in NSW was 70.65% higher than expected claims in 2015/16. On a post-tax basis, this becomes 1.09 / 0.586 – 1 = 86.01%, which is an increase of 21.7% from a tax on premiums of 9% (roughly 2.4 times the size of the tax). The price elasticity of demand can be related to the elasticity w.r.t tax by -1.34 / 2.4 = -0.56, which is the calibrated price elasticity of demand for ESL-liable general insurance demanded by households in VURMTAX. While some ESL load falls on industries, we retain the usual Leontief demand structure by industries for intermediate inputs to production that underpins VURM and VURMTAX [see Adams *et al.* (2015)].

Herein, we model property transfer duty using the approach described by Nassios and Giesecke (2022), identifying four channels via which transfer duties affect the real economy:

1. *Transfer duties on existing housing*. These duties fall on household purchases of services that facilitate the transfer of ownership of housing (viz. building inspection services, real estate agent services, legal conveyancing services, and public administration). The resulting indirect tax rates are large, as denoted in Figure 1 herein.
2. *Transfer duties on new housing*. These duties fall on investors installing new units of housing capital. In VURMTAX, these duties are paid by households, with the housing sector overwhelmingly domestically-owned.
3. *Transfer duties on existing commercial, industrial and agricultural properties*. Similar to channel 1 above, duties are liable when transferring ownership of non-residential property. Herein, these duties are incident on the services purchased to facilitate the transfer of ownership.
4. *Transfer duties on new commercial, industrial and agricultural properties*. These duties fall on local and foreign investors installing new units of non-residential capital.

In order to model channel 1, four new commodities are introduced to the model. These commodities reflect the real estate, legal (conveyancing), public administration and property inspection/engineering services households and industries purchase in order to facilitate the transfer of property. We then introduce a service bundle in the linear expenditure system governing the households' consumption decisions in VURMTAX, called *Moving services*. *Moving services* is a Leontief aggregate of the four aforementioned commodities. Sales taxes on this bundle of goods are linked to property transfer duty revenue from existing residential property sales, which are set according to a progressive rate schedule using the approach in Nassios and Giesecke (2022). Channel 2 is modelled via the introduction of production taxes on the formation of new units of dwelling capital.

To account for channel 3, we introduce the *Moving services* Leontief bundle into the intermediate input mix of industries in VURMTAX. Demand for this bundle is proportional to industry output levels. In VURMTAX, changes in conveyancing duty on non-residential property thus enter into industry production costs, which has general equilibrium consequences for regional employment, investment, GSP and so forth. Finally, channel 4 is modelled in a similar way to channel 2, with production taxes imposed on new non-residential capital investment.

In this paper, the marginal excess burdens for transfer duties we report are derived from simulations where the duty rates for each of channels 1 – 4 are adjusted by uniform percentage amounts, in each region the duties are collected.

2.6. Deriving marginal excess burdens in VURMTAX

In this paper, we follow the approach by Nassios *et al.* (2019a; 2019b), Adams et al. (2020) and Nassios and Giesecke (2022), by deriving tax-specific marginal excess burdens (MEBs) using VURMTAX. Because VURMTAX is dynamic, it can calculate year-on-year marginal excess burden measures. More specifically, we evaluate the efficiency loss caused by an adjustment to tax instrument *k*, where $k \in [\mathrm{PIT}, \mathrm{GST}, \mathrm{TD}, \mathrm{ID}]$, at time-period *t* at the national (Australia-wide) level (denoted MEB_{k}^{t}) according to:

$$\mathrm{MEB}_{k}^{t} = -100 \left[\frac{\Delta \mathrm{GNI}^{t} + \sum_{q} \mathrm{VLEIS}_{q}^{t}}{\sum_{g} \Delta \mathrm{LST}_{g}^{t}} \right], \tag{4}$$

where:

$\Delta \mathrm{GNI}^{t}$	is the deviation between the year *t* counterfactual and BAU forecast value of real gross national income (deflated by a gross national expenditure (GNE) divisia price index and measured in A$m);
$\Delta \mathrm{VLEIS}_{q}^{t}$	is the deviation in the value of leisure time consumed by residents in region *q* in year *t*, valued at the BAU forecast real consumer wage rate [see Nassios et al. (2019a; 2019b) for a description];
$\Delta \mathrm{LST}_{g}^{t}$	is the value of budget-balance neutralising lump sum payments to households by government agent *g*, i.e., the NSW and RoA state/local government agent, or the Federal government.

With underlying databases reflective of current tax loads by user, and parameter specifications that accurately capture decision making sensitivities to tax policy changes, CGE models are well-suited to deriving MEBs for the current tax system. This is demonstrated by Nassios *et al.* (2019a; 2019b), Adams *et al.* (2020), Giesecke *et al.* (2021), and Nassios and Giesecke (2022), in which MEBs for thirty-seven Australian taxes are derived via equation (4) using counterfactual scenarios where small reductions or increases in tax-specific revenue typically worth A$100m are simulated, under the assumption of a balanced government budget. The resulting MEB yields a point estimate of the deadweight cost of a marginal adjustment in tax-specific revenue, at the current tax-specific revenue-to-GDP ratio.

As discussed by Harberger (1962) and more recently by Creedy (2003) however, the MEB of a tax is an increasing function of its tax rate. When studying revenue-neutral adjustments to a given tax mix, i.e., swapping revenue of one tax for that of another, the aim is to propose a redesigned tax mix that is less distortionary than the current one, i.e., one that carries a lower excess burden. This requires an understanding not only of the current MEBs of all taxes, but also how sensitive each of these MEBs are to changes in tax rates or a relevant proxy (such as tax-specific revenue-to-GDP ratios).

In this paper, we define the relationship between the MEB of a given tax and its revenue-to-GDP ratio as the MEB distribution function. We use VURMTAX to illustrate how a series of counterfactual scenarios simulated using a CGE model can be used to derive MEB distribution functions. Our computationally-intensive approach is presented via example for four Australian taxes. For each tax, we perform a series of twenty-three counterfactual simulations where we derive results for $\Delta\mathrm{GNI}^{2040}$, $\Delta\mathrm{VLEIS}_{\mathrm{q}}^{2040}$ and $\Delta\mathrm{LST}_{\mathrm{g}}^{\mathrm{t}}$ for all $q \in [\mathrm{NSW}, \mathrm{RoA}]$ and $g \in [\mathrm{NSW}, \mathrm{RoA}, \mathrm{Federal}]$, across the four taxes *k* we described in section 2.2 – 2.5, i.e., $k \in [\mathrm{PIT}, \mathrm{GST}, \mathrm{TD}, \mathrm{ID}]$. For each *k,* the twenty-three simulations allow us to study how $\Delta\mathrm{GNI}^{2040}$, $\Delta\mathrm{VLEIS}_{\mathrm{q}}^{2040}$, and $\Delta\mathrm{LST}_{\mathrm{g}}^{\mathrm{t}}$ vary across the range $\left[0.01T_{\mathrm{k}}^{\mathrm{base}}, T_{\mathrm{k}}^{\mathrm{base}}, 1.99T_{\mathrm{k}}^{\mathrm{base}}\right]$, where $T_{\mathrm{k}}^{\mathrm{base}}$ is the baseline forecast level of the tax rate for tax type *k*. We can define the sample range more simply as:

$$a_{\mathrm{i}} \cdot T_{\mathrm{k}}^{\mathrm{initial}}, \qquad \text{where } i \in \{1, 2, 3, \ldots, 23\},\ a_1 = 0.01, \text{ and } a_{\mathrm{n}+1} = a_{\mathrm{n}} + 0.09. \tag{5}$$

The MEB distribution function $\mathrm{MEB}_{\mathrm{k}}^{\mathrm{t}}\left(a_{\mathrm{i}} \cdot T_{\mathrm{k}}^{\mathrm{initial}}\right)$, is then defined as:

$$\mathrm{MEB}_{\mathrm{k}}^{\mathrm{t}}\left(a_{\mathrm{i}}\cdot T_{\mathrm{k}}^{\mathrm{initial}}\right)=-100\begin{cases}\left[\dfrac{\left(\Delta\mathrm{GNI}_{\mathrm{i}}^{\mathrm{t}}-\Delta\mathrm{GNI}_{\mathrm{i+1}}^{\mathrm{t}}\right)+\sum_{\mathrm{q}}\left(\mathrm{VLEIS}_{\mathrm{q,i}}^{\mathrm{t}}-\mathrm{VLEIS}_{\mathrm{q,i+1}}^{\mathrm{t}}\right)}{\sum_{\mathrm{g}}\left(\Delta\mathrm{LST}_{\mathrm{g,i}}^{\mathrm{t}}-\Delta\mathrm{LST}_{\mathrm{g,i+1}}^{\mathrm{t}}\right)}\right] & \mathrm{a_i}<1\\ \left[\dfrac{\Delta\mathrm{GNI}_{\mathrm{i}}^{\mathrm{t}}+\sum_{\mathrm{q}}\mathrm{VLEIS}_{\mathrm{q,i}}^{\mathrm{t}}}{\sum_{\mathrm{g}}\Delta\mathrm{LST}_{\mathrm{g,i}}^{\mathrm{t}}}\right] & \mathrm{a_i}=1\ .\\ \left[\dfrac{\left(\Delta\mathrm{GNI}_{\mathrm{i+1}}^{\mathrm{t}}-\Delta\mathrm{GNI}_{\mathrm{i}}^{\mathrm{t}}\right)+\sum_{\mathrm{q}}\left(\mathrm{VLEIS}_{\mathrm{q,i+1}}^{\mathrm{t}}-\mathrm{VLEIS}_{\mathrm{q,i}}^{\mathrm{t}}\right)}{\sum_{\mathrm{g}}\left(\Delta\mathrm{LST}_{\mathrm{g,i+1}}^{\mathrm{t}}-\Delta\mathrm{LST}_{\mathrm{g,i}}^{\mathrm{t}}\right)}\right] & \mathrm{a_i}>1\end{cases}\qquad\textbf{(6)}$$

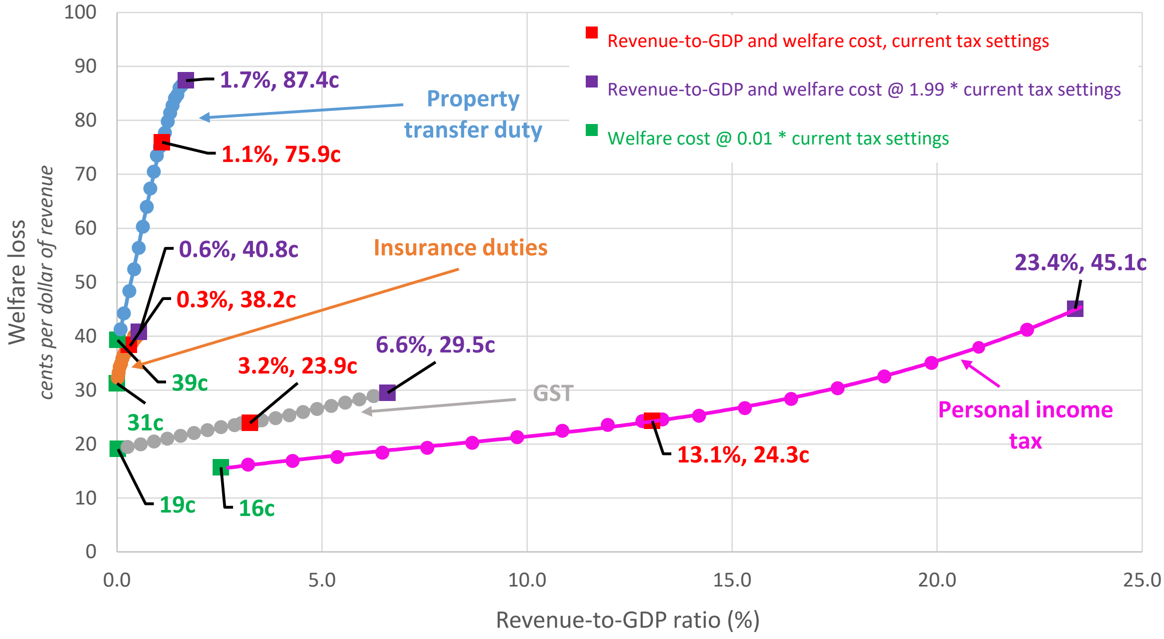
Because the tax bases for each tax we study differ significantly, plotting the MEB distribution functions against tax rates is inappropriate. Instead, plotting MEBs against tax-specific revenue-to-GDP ratios for each tax allow us to compare MEB distribution functions across taxes. At each $a_{\mathrm{i}}\cdot T_{\mathrm{k}}^{\mathrm{initial}}$ for $i\in\{1,2,3,\ldots,23\}$ and each $k\in[\mathrm{PIT},\mathrm{GST},\mathrm{TD},\mathrm{ID}]$, we therefore also report the tax-specific revenue-to-GDP ratio from VURMTAX. Reporting results in this way also facilitates use of the curves for tax-mix swap analysis.

3. Results

The results of the ninety-two simulations we perform yield the MEB distribution functions $\mathrm{MEB}_{\mathrm{k}}^{2040}\left(a_{\mathrm{i}}\cdot T_{\mathrm{k}}^{\mathrm{initial}}\right)$ in Figure 2. Along the vertical axis in Figure 2, we plot $\mathrm{MEB}_{\mathrm{k}}^{2040}\left(a_{\mathrm{i}}\cdot T_{\mathrm{k}}^{\mathrm{initial}}\right)$ for all $i\in\{1,2,3,\ldots,23\}$, measured in cents per dollar of revenue raised.

In the upper left of Figure 2, the blue and orange lines sketch the MEB distribution functions for property transfer and insurance duties, respectively. The narrow-base of each tax is evident in the high and steep MEB gradients exhibited in Figure 2, certainly relative to the broader-based GST (grey circles) and personal income tax (magenta circles). The current MEB and revenue-to-GDP ratio for each tax are highlighted in red squares and text in Figure 2, with property transfer duties carrying the largest current MEB (75.9 cents per dollar). Interestingly, despite different ratios of revenue-to-GDP, the GST and personal income tax exhibit similar MEBs of approximately 24 cents per dollar, indicating that policy makers have arrived at about the right mix of GST (3.2% revenue-to-GDP) and personal income tax (13.1% revenue-to-GDP) in Australia. The green squares marked on the TD (39 cents per dollar) and ID (31 cents per dollar) curves are the MEBs for each tax at very low revenue raising capacity, i.e., when each tax is levied at a rate that is 1 percent of its current rate. Despite very low revenue raising capacity at these tax rates, the MEBs exceed the current MEBs (red squares) for both the GST and PIT. In order to justify raising small amounts of ID revenue, the revenue-to-GDP ratio of the GST would have to be twice as large (see the purple squares in Figure 2 which, for the GST, show its MEB to be 29.5 cents at 6.6 percent revenue-to-GDP, a level that nevertheless still lies below the lower bound MEB for ID of 31 cents), while PIT revenue shares would also need to increase by at least 3 percentage points of GDP, from 13.1 percent to about 16 percent. The case for raising even small amounts of TD revenue are weaker still: the GST revenue share would need to be well in excess of 10 percent of GDP, while the PIT revenue share would need to be about 21 percent of GDP. TDs and IDs could therefore only be justified in Australia's tax mix under public finance scenarios in which the aggregate tax take represented a much higher share of GDP than at present.

Figure 2: Marginal excess burdens at different revenue raising efforts



Notes: Marginal excess burden (y-axis) relative to the ratio of revenue-to-GDP (x-axis) for insurance duties (orange circles), property transfer duties (blue circles), the GST (grey circles) and personal income tax (magenta circles) in Australia, derived using VURMTAX. Lines represent the plots of the functions in equation (7) and are colour-coded to match the aforementioned tax instruments.

With the data points underpinning the plots in Figure 2 in hand, we use Ordinary Least Squares (OLS) to derive lines of best fit for each $k \in \left[\text{PIT}, \text{GST}, \text{TD}, \text{ID}\right]$.[4] We assessed a variety of polynomial functional relationships between $\text{MEB}_{\text{k}}^{2040}\left(a_{\text{i}} \cdot T_{\text{k}}^{\text{initial}}\right)$ and the revenue-to-GDP ratio (R2GDP henceforth) for each $k \in \left[\text{PIT}, \text{GST}, \text{TD}, \text{ID}\right]$. In each case, we perform a series of F-tests of overall

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[4] An alternative approach would be to interpolate the data points derived from VURMTAX simulations, e.g., using cubic splines. Our OLS regressions exhibit small standard errors, adjusted R-squared coefficients close to 1, and F-test *p*-values very close to zero. The resulting formulae are also more readily applied by readers. We therefore felt the use of cubic spline interpolation was not necessary.

significance and report results for the model that exhibited the smallest *p*-value for each tax *k* in equation (7):

$$\mathrm{MEB}_{\mathrm{GST}}^{2040}\left(\mathrm{R2GDP}\right)=19.1^{***}+1.55^{***}\,\mathrm{R2GDP}, \tag{7a}$$

$$\mathrm{MEB}_{\mathrm{PIT}}^{2040}\left(\mathrm{R2GDP}\right)=12.6^{***}+1.30^{***}\,\mathrm{R2GDP}-0.076^{***}\,\mathrm{R2GDP}^{2}+0.0034^{***}\,\mathrm{R2GDP}^{3}, \tag{7b}$$

$$\mathrm{MEB}_{\mathrm{ID}}^{2040}\left(\mathrm{R2GDP}\right)=31.5^{***}+43.6^{***}\,\mathrm{R2GDP}-91.7^{***}\,\mathrm{R2GDP}^{2}+78.6^{***}\,\mathrm{R2GDP}^{3}, \tag{7c}$$

$$\mathrm{MEB}_{\mathrm{TD}}^{2040}\left(\mathrm{R2GDP}\right)=38.7^{***}+29.6^{***}\,\mathrm{R2GDP}+13.1^{***}\,\mathrm{R2GDP}^{2}-8.05^{***}\,\mathrm{R2GDP}^{3}. \tag{7d}$$

Every coefficient reported in equation (7) was significant at the 99% confidence level (as denoted by the superscript asterisks "***"), while each model in equation (7) exhibited an adjusted-R^2 in excess of 99 percent. We plot each model in equation (7) in Figure 2 as coloured lines, to facilitate a direct comparison of equation (7) and the simulated outputs from VURMTAX. For example, equation (7b) is represented in Figure 2 by the magenta line. This line clearly demonstrates excellent agreement with each of the magenta circles that represent the CGE-simulated personal income tax MEB distribution function, providing a visual cue that (7b) is a good fit. The plots for equations (7a) [GST, grey line], (7c) [ID, orange line] and (7d) [TD, blue line] demonstrate similarly good agreement with VURMTAX outputs in Figure 2.

While implicitly based on CGE model simulation outputs, the formulae in equation (7) facilitate rapid assessment of the welfare implications of revenue-neutral tax-mix changes, as we now demonstrate. First, evaluating equations (7c) and (7d) at R2GDP =0, we see that the MEBs for insurance duties (31 cents per dollar) and property transfer duties (39 cents per dollar) exceed the current MEBs for both the GST and personal income tax (24 cents per dollar, red squares in Figure 2). This does not directly imply replacement of either (or both) state tax with an increase in GST or PIT collections to be optimal, however, because lifting the rate of the GST and PIT will increase their MEBs. Using equation (7a), we can assess the degree to which the MEB of the GST will increase if it is used to replace both state taxes, whose collections are worth about 1.4 percent of GDP annually by 2040. The target revenue-to-GDP ratio for the GST in 2040 under full replacement, i.e., TD and ID -> GST, is R2GDP = 3.2+1.4 = 4.6 percent; substituting this into the right-hand-side of equation (7a) yields $\mathrm{MEB}_{\mathrm{GST}}^{2040}=26.2$ cents per dollar, a rise relative to the current MEB of about 2.3 cents per dollar. Importantly, this remains well below the zero-rate MEBs for both insurance duties (31 cents per dollar) and transfer duties (39 cents per dollar). Property transfer and insurance duties are thus inefficient at any level, relative to a system where the GST rate is raised by a sufficient amount to leave economy-wide tax revenues unchanged. Welfare can be improved if both are eliminated entirely and replaced via a rise in the GST rate.

Can the welfare improvement be amplified if revenue is replaced with a rise in the average personal income tax rate, instead of a rise in the GST rate? To assess this, we follow a similar process only using equation (7b). The target level for revenue-to-GDP for the personal income tax under full replacement is R2GDP = 13.1+1.4 = 14.5 percent, and substituting this into the right-hand-side of equation (6b) yields $\text{MEB}_{\text{PIT}}^{2040} = 25.7$ cents per dollar, a rise of 1.4 cents per dollar relative to the current level. This 1.4 cent per dollar rise in $\text{MEB}_{\text{PIT}}^{2040}$ is smaller than the 2.3 cent per dollar rise in $\text{MEB}_{\text{GST}}^{2040}$ calculated from an identical 1.4 percent rise in revenue-to-GDP. On economic efficiency grounds, replacement of property transfer and insurance duties with a rise in the average personal income tax rate yields a greater uplift in welfare than replacement of both state taxes with a rise in the GST rate.

Because the PIT and GST currently exhibit similar MEBs, at around 24 cents, a rise in revenue-to-GDP of one of these taxes will push its MEB above that of the other tax. For example, if both state taxes are replaced by the PIT, its MEB will rise to 25.7 cents per dollar, which would then exceed that of the GST. We can thus go one step further, and use equation (7) to determine a reform package where the 1.4 percent of additional revenue-to-GDP required to fully replace both state taxes is distributed across the GST and PIT in such a way that the final MEBs of each tax are equal. In what follows, we illustrate how equations (7a) and (7b) can be solved for these shares. Let *A* be the increase in revenue-to-GDP for the GST, with *B* the corresponding uplift in PIT revenue-to-GDP. The sum of these quantities is equal to 1.4, which is the revenue-to-GDP ratio for both state taxes we seek to replace:

$$1.4 = A + B. \qquad \textbf{(8)}$$

To solve for *A* and *B* we set R2GDP for the PIT in equation (7b) to 13.1+*B,* and R2GDP for the GST in equation (7a) equal to 3.2+*A*. Because we seek solutions for *A* and *B* that yield $\text{MEB}_{\text{PIT}}^{2040} = \text{MEB}_{\text{GST}}^{2040}$, we set equations (7a) and (7b) equal to one another and solve them simultaneously under the constraint in equation (8). We find the $\text{MEB}_{\text{PIT}}^{2040} = 25 = \text{MEB}_{\text{GST}}^{2040}$ when $A = 0.65$ and $B = 0.72$, i.e., the MEBs are equal under the reform package when 48% (=0.65/1.4) of the foregone state tax revenue is replaced via a rise in the GST rate, and the remaining 52% is replaced via an increase in the average PIT rate.

With equation (7) in place, we have the capacity to explore changes to the tax system that equalise MEBs across a suite of taxes. However, as we now demonstrate, a change in the independent variable can enhance the efficacy of our approach. In place of R2GDP, i.e., the ratio of tax-specific revenue to GDP in 2040, as the independent variable, in what follows we set the independent variable in all regressions to the denominator in the $\mathrm{MEB}_{\mathrm{k}}^{2040}\left(a_{\mathrm{i}}\cdot T_{\mathrm{k}}^{\mathrm{initial}}\right)$ from equation (6), which is the deviation in the real national budget-neutralising lump sum tax on households in A$m. Why? Doing so allows us to calculate definite integrals of our regression equations, and interpret the results of those definite integrals as real welfare (in A$m in 2040) responses to tax policy changes. With the dependent variable remaining unchanged, i.e., $\mathrm{MEB}_{\mathrm{k}}^{2040}\left(a_{\mathrm{i}}\cdot T_{\mathrm{k}}^{\mathrm{initial}}\right)$ is the dependent variable, we re-run our OLS regressions, yielding the following set of OLS outputs:

$$\mathrm{MEB}_{\mathrm{GST}}^{2040}\left(\mathrm{LST}\right)=24.1^{***}+4.34\times10^{-5^{***}}\,\mathrm{LST}+4.37\times10^{-16^{***}}\,\mathrm{LST}^{2}, \qquad \textbf{(9a)}$$

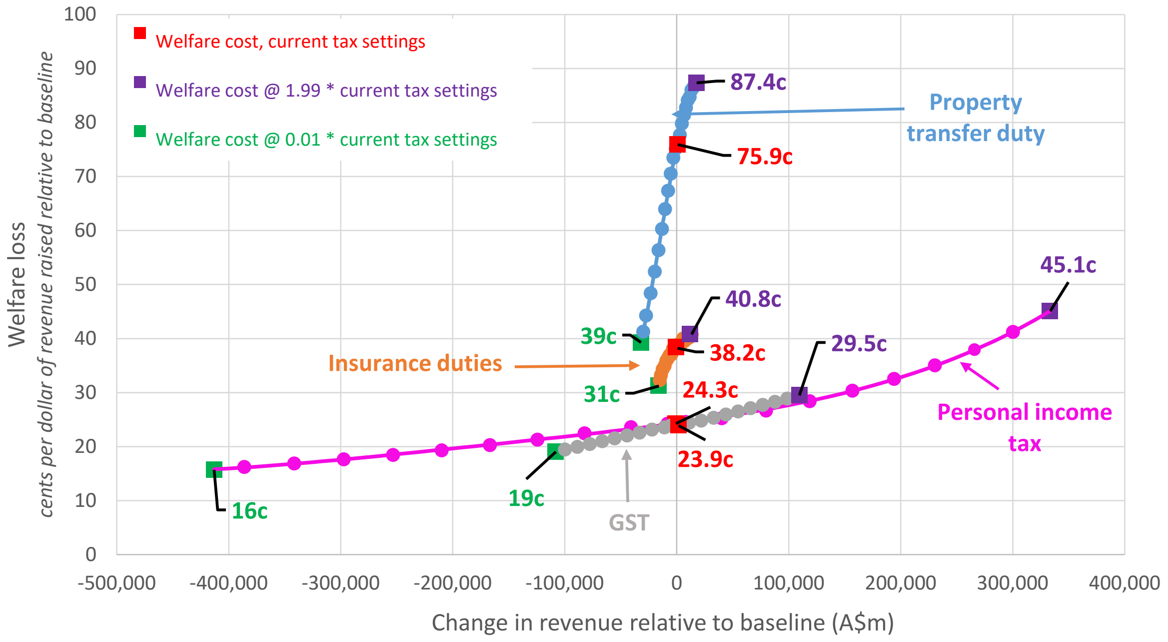
$$\mathrm{MEB}_{\mathrm{PIT}}^{2040}\left(\mathrm{LST}\right)=24.3^{***}+2.78\times10^{-5^{***}}\,\mathrm{LST}+4.04\times10^{-11^{***}}\,\mathrm{LST}^{2}+1.3\times10^{-16^{***}}\,\mathrm{LST}^{3}+1.78\times10^{-22^{***}}\,\mathrm{LST}^{4}, \qquad \textbf{(9b)}$$

$$\mathrm{MEB}_{\mathrm{ID}}^{2040}\left(\mathrm{LST}\right)=31.5^{***}+1.85\times10^{-4^{***}}\,\mathrm{LST}-7.2\times10^{-9^{***}}\,\mathrm{LST}^{2}+5.35\times10^{-13^{***}}\,\mathrm{LST}^{3}, \qquad \textbf{(9c)}$$

$$\mathrm{MEB}_{\mathrm{TD}}^{2040}\left(\mathrm{LST}\right)=75.6^{***}+1.02\times10^{-3^{***}}\,\mathrm{LST}-1.4\times10^{-8^{***}}\,\mathrm{LST}^{2}-3.3\times10^{-13^{***}}\,\mathrm{LST}^{3}. \qquad \textbf{(9d)}$$

Equation (9) is similar to equation (7), however the intercept is now $\mathrm{MEB}_{\mathrm{k}}^{2040}\left(T_{\mathrm{k}}^{\mathrm{initial}}\right)$ whereas in equation (7), the intercept was equal to $\mathrm{MEB}_{\mathrm{k}}^{2040}\left(0.01\cdot T_{\mathrm{k}}^{\mathrm{initial}}\right)$. The coefficients in equation (9) are also several orders of magnitude smaller than those in equation (7), because the independent variable is measured in A$m rather than per cent. Nevertheless, the plots of equation (9) show similarly good agreement with modelled results from VURMTAX; see Figure 3, where we plot simulated outputs and equation (9).

Figure 3: Marginal excess burdens at different levels of budget-neutralising lump sum transfer levels



Notes: Marginal excess burden (y-axis) relative to the denominator in the marginal excess burden formula, the A$m deviation in the national public sector budget position from the baseline (x-axis). We include plots for insurance duties (orange circles), property transfer duties (blue circles), the GST (grey circles) and personal income tax (magenta circles) in Australia, derived using VURMTAX. Lines represent plots of the functions in equation (9) and are colour-coded to match the aforementioned tax instruments.

Like we showed for equation (7), equation (9) can also be solved for the GST and PIT tax mix that equalises the two tax-specific MEBs, and raises enough revenue to replace both IDs and TDs. Doing so yields revenue shares that match those derived from equation (7), i.e., 48% GST and 52% PIT. For brevity, we do not repeat this process here. Because the explanatory variable is equal to the denominator of the dependent variable in equation (9), we can calculate $\Delta\text{WELF}_k^{2040}$, the change in real welfare in 2040 (in A$m) caused by a change in the rate of tax instrument $k\in\left[\text{PIT},\text{GST},\text{TD},\text{ID}\right]$, by evaluating the definite integral of equation (9). The integration interval is $\left[0,\text{LST}_k^{\text{TARG},2040}\right]$, where $\text{LST}_k^{\text{TARG},2040}$ is the change in the national public sector budget position relative to baseline, when the rate of a tax instrument $k\in\left[\text{PIT},\text{GST},\text{TD},\text{ID}\right]$ is altered relative to its BAU forecast level. See equation (10), where we define $\Delta\text{WELF}_k^{2040}$ algebraically:

$$\Delta\text{WELF}_k^{2040}\left(\text{LST}_k^{\text{TARG},2040}\right)=\frac{1}{100}\cdot\int_{\text{LST}_k^{\text{TARG},2040}}^{0}\text{MEB}_k^{2040}\left(\text{LST}\right)\;d\text{LST}, \tag{10}$$

where the factor of 1/100 in equation (10) accounts for the units of the MEB (cents per dollar of LST). Substituting equation (9) into (10) then yields the set of welfare functions reported in equation (11):

$$\Delta \mathrm{WELF}_{\mathrm{GST}}^{2040}\left(\mathrm{LST}_{\mathrm{GST}}^{\mathrm{TARG},2040}\right)=24.1\left(\mathrm{LST}_{\mathrm{GST}}^{\mathrm{TARG},2040}\right)+\frac{4.34\times 10^{-5}}{2}\left(\mathrm{LST}_{\mathrm{GST}}^{\mathrm{TARG},2040}\right)^{2}+\frac{4.37\times 10^{-16}}{3}\left(\mathrm{LST}_{\mathrm{GST}}^{\mathrm{TARG},2040}\right)^{3}, \tag{11a}$$

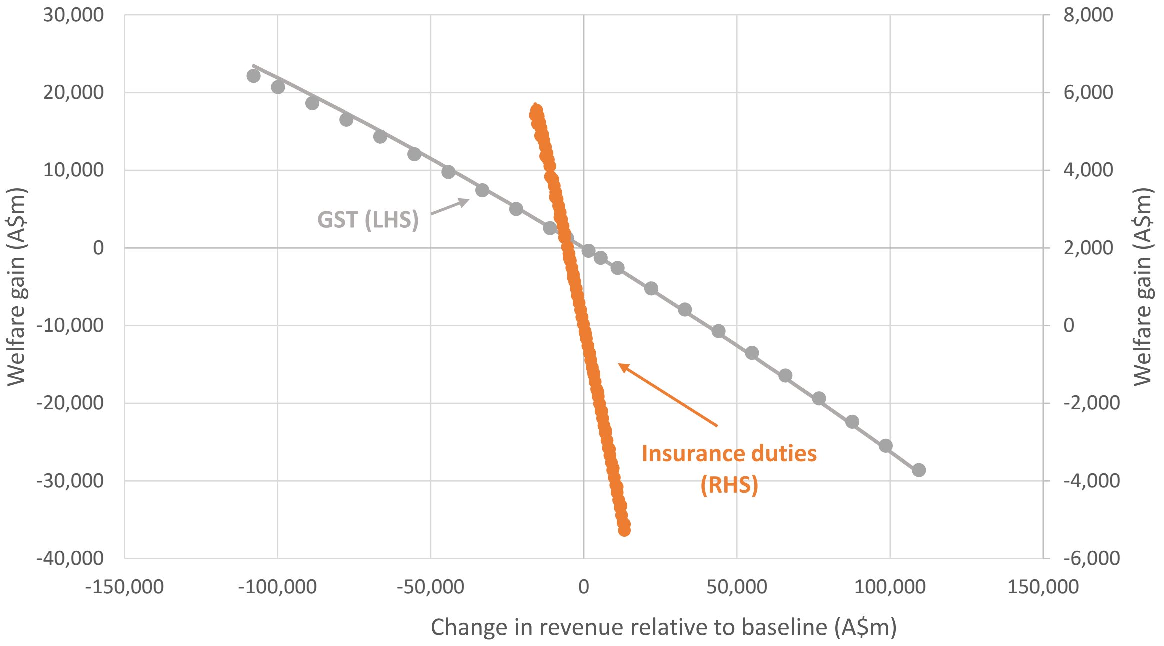
$$\begin{aligned}\Delta \mathrm{WELF}_{\mathrm{PIT}}^{2040}\left(\mathrm{LST}_{\mathrm{PIT}}^{\mathrm{TARG},2040}\right)=\;&24.3\left(\mathrm{LST}_{\mathrm{PIT}}^{\mathrm{TARG},2040}\right)+\frac{2.78\times 10^{-5}}{2}\left(\mathrm{LST}_{\mathrm{PIT}}^{\mathrm{TARG},2040}\right)^{2}+\frac{4.04\times 10^{-11}}{3}\left(\mathrm{LST}_{\mathrm{PIT}}^{\mathrm{TARG},2040}\right)^{3}\\&+\frac{1.3\times 10^{-16}}{4}\left(\mathrm{LST}_{\mathrm{PIT}}^{\mathrm{TARG},2040}\right)^{4}+\frac{1.78\times 10^{-22}}{5}\left(\mathrm{LST}_{\mathrm{PIT}}^{\mathrm{TARG},2040}\right)^{5},\end{aligned} \tag{11b}$$

$$\begin{aligned}\Delta \mathrm{WELF}_{\mathrm{ID}}^{2040}\left(\mathrm{LST}_{\mathrm{ID}}^{\mathrm{TARG},2040}\right)=\;&31.5\left(\mathrm{LST}_{\mathrm{ID}}^{\mathrm{TARG},2040}\right)+\frac{1.85\times 10^{-4}}{2}\left(\mathrm{LST}_{\mathrm{ID}}^{\mathrm{TARG},2040}\right)^{2}-\frac{7.2\times 10^{-9}}{3}\left(\mathrm{LST}_{\mathrm{ID}}^{\mathrm{TARG},2040}\right)^{3}\\&+\frac{5.35\times 10^{-13}}{4}\left(\mathrm{LST}_{\mathrm{ID}}^{\mathrm{TARG},2040}\right)^{4},\end{aligned} \tag{11c}$$

$$\begin{aligned}\Delta \mathrm{WELF}_{\mathrm{TD}}^{2040}\left(\mathrm{LST}_{\mathrm{TD}}^{\mathrm{TARG},2040}\right)=\;&75.6\left(\mathrm{LST}_{\mathrm{TD}}^{\mathrm{TARG},2040}\right)+\frac{1.02\times 10^{-3}}{2}\left(\mathrm{LST}_{\mathrm{TD}}^{\mathrm{TARG},2040}\right)^{2}-\frac{1.4\times 10^{-8}}{3}\left(\mathrm{LST}_{\mathrm{TD}}^{\mathrm{TARG},2040}\right)^{3}\\&-\frac{3.3\times 10^{-13}}{4}\left(\mathrm{LST}_{\mathrm{TD}}^{\mathrm{TARG},2040}\right)^{4}.\end{aligned} \tag{11d}$$

Because these equations are integrals of OLS estimates, they carry greater error than the original OLS estimates of the MEB distribution functions themselves, which showed excellent agreement with our VURMTAX simulation outputs; see Figures 2 and 3. The relative error in the welfare change estimates is generally 5% or less, if the associated MEB distribution functions from equation (9) were relatively smooth. This is true for both IDs, and the GST; see Figure 4, where we plot equations (11a) and (11c) as solid grey and orange lines, respectively, against our simulated welfare responses for the GST (grey circles) and ID (orange circles).

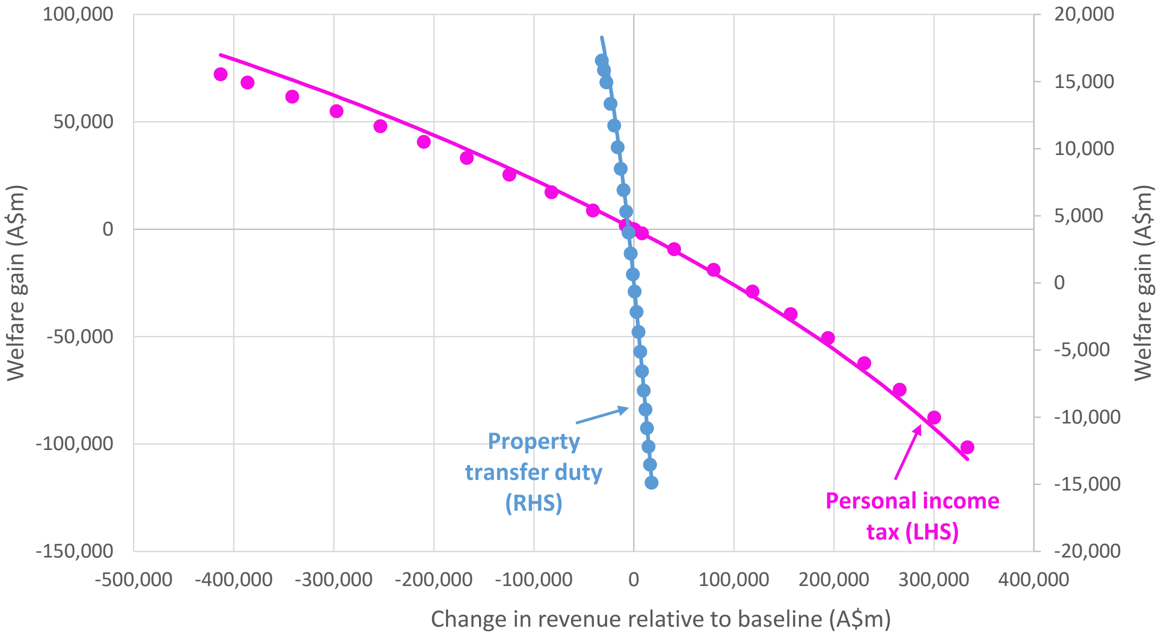
Figure 4: Welfare change at different levels of budget-neutralising lump sum transfer levels: GST and ID



Notes: Welfare change in A$m (y-axis), relative to the A$m deviation in the national public sector budget position from the baseline (x-axis) for the GST (grey circles) and insurance duties (orange circles) in Australia, derived using VURMTAX. Lines represent the plots of the functions in equation (11a) and (11c), and are colour-coded to match the aforementioned tax instruments. Relative errors between the solid lines and simulation outputs/coloured dots are no larger than 5%.

For the PIT and TDs, the relative errors are larger (12 percent or lower); they are largest when the associated MEB distribution functions exhibit greater convexity. See Figure 5, where we plot equations (11b) and (11d) as solid magenta and blue lines, respectively, against our simulated welfare responses for PIT (magenta circles) and TD (blue circles). The largest relative errors in the welfare estimates materialise for large increases (decreases) in revenue, or when tax rates are being heavily increased (reduced). In future work, we plan to increase the granularity of VURMTAX simulations for MEB distribution functions in these regions, e.g., by altering the step size in equation (5) from 0.09 in these regions to something smaller like 0.045. An alternative would be to apply a curve fitting algorithm, e.g., piecewise polynomials like cubic splines. The disadvantage of this approach is that the outputs cannot be written succinctly, because many polynomials will be derived to fit curves using adjacent blue, grey, orange and magenta dots, for each of the MEB distribution functions in Figures 2 and 3.

Figure 5: Welfare change at different levels of budget-neutralising lump sum transfer levels: PIT and TD



Notes: Welfare change in A$m (y-axis), relative to the A$m deviation in the national public sector budget position from the baseline (x-axis) for personal income tax (magenta circles) and property transfer duties (blue circles) in Australia, derived using VURMTAX. Lines represent the plots of the functions in equation (11b) and (11d), and are colour-coded to match the aforementioned tax instruments. Note that deviations between the solid lines and VURMTAX simulated results materialise where the associated MEB distribution functions in Figure 3 also exhibit convexity.

With equation (11) in place users can augment their analysis of tax mix swaps with other variables of interest to policy makers, such as estimates of real welfare responses. For example, if TD and ID are forecast to collectively yield A$48b in real revenues by 2040, from equation (11a) we see that raising the GST rate in order to generate this amount of real revenue will reduce welfare by approximately A$12b, while generating the same amount of real revenue via a PIT rate rise will reduce welfare by A$11.98b. As expected, the GST rate rise carries a larger cost than the average PIT rate rise, although the differences are small. Note that neither of these estimates account for the rise in welfare generated from removal of the inefficient state taxes; from equations (11c) and (11d), this is expected to increase welfare by A$5.7b and A$18.3b, respectively, exceeding the costs associated with the increase in either GST or PIT collections by approximately A$12b (=5.7+18.3-12). Using central estimates from the ABS Household and Family Projections, this equates to approximately $935 per household in 2040.[5]

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[5] See https://www.abs.gov.au/statistics/people/population/household-and-family-projections-australia/2016-2041. The figures presented by the ABS are forecasts to 2041.The implied annual growth rate in households in the forecasts is 1.4%. We adjust the ABS central estimates (series 2) to remove one years' worth of growth and align the forecasts with the final year of the modelling presented herein, which is 2040. This leaves us with a household count of 12.84m.

4. Concluding remarks and future work

In this paper, we have used a multi-region, multi-industry CGE model of the Australian economy with tax detail to derive functional relationships between the marginal excess burden (MEB) of four Australian taxes, and their tax-specific revenue-to-GDP ratios. For each of the resulting four MEB distribution functions, OLS is applied to yield polynomial expressions between the tax-specific MEB and its revenue-to-GDP ratio. As we demonstrate, the resulting formulae expedite the analysis of revenue-neutral tax reform scenarios. For example, two of the four taxes we study (insurance and property transfer duties) exhibit very high MEBs at their current revenue-to-GDP ratios. Assuming revenue neutrality, we used the MEB distribution functions derived herein to understand whether (i) there was any level of revenue-to-GDP where these inefficient taxes exhibit similar MEBs to broader-based taxes like the GST and personal income tax; and (ii) replacement of both inefficient taxes via increases in the GST rate or the average personal income tax rate was preferable when seeking to maximise the welfare gain. By evaluating equations (7c) and (7d) herein at revenue-to-GDP ratios of zero, we show that both narrow-based taxes cause deadweight losses that exceed those caused by the GST and personal income tax, even at infinitesimally small levels of revenue. This suggests both of the two narrow-based state taxes we study are inefficient at any tax rate and should be eliminated. As we argue, only at very large aggregate revenue-to-GDP ratios could either of the state taxes we study be justified.

By studying how the MEB of the GST and personal income tax change as we increase their revenue-to-GDP ratios, we show that from an economic efficiency perspective, if we can choose only one replacement tax, then an increase in the average personal income tax rate is the preferred tool. But if policy makers can increase both the GST and the personal income tax rate, then an approximate 48%/52% split in the revenue raising effort across the two taxes is more efficient. As we showed, the utility of our approach can be expanded to facilitate a study of the impact of tax mix swaps on real welfare, by altering the explanatory variable in our OLS regressions. Our application of the welfare equations derived herein suggest that removal of the two inefficient taxes we study, funded via a 48/52 GST/PIT revenue increase, could improve welfare by approximately A$935 per household in real terms by 2040. In future work, we plan to improve the accuracy of our welfare functions, by increasing the density of our sampling frequency when tax rates are rising or falling significantly.

In addition, we plan to expand the range of taxes for which we estimate the MEB distribution functions reported in Figures 2 and 3 and equations (7) and (9). This will allow us to compare Australia’s current tax mix to a range of alternatives. These alternatives could span a wide range of possibilities. At the politically-ambitious end of this range, we can investigate the properties of a system-wide optimum, in which marginal excess burdens are equalised across all tax instruments under a given aggregate revenue-to-GDP target. More practically, the system can be used to inform policy makers on a variety of more circumscribed tax swap packages that nevertheless aim to maximise welfare gains but within the constraints of what might be politically feasible.

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