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Efficiency of the tax system: a marginal excess burden analysis

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Abstract

This paper analyses the efficiency of the Australian tax system using CGETAX, a large-scale, long-run CGE model designed for tax policy analysis. This follows an analysis with CGETAX of an Australian Government proposal to reduce the corporate tax rate from 30 to 25 per cent in Murphy (2016a) and Murphy(2016b) and an Australian Treasury Working Paper on the efficiency of certain taxes (Cao et al., 2015). This paper begins by uses a highly stylised version of CGETAX to provide a theoretical analysis of the efficiency of major taxes, applicable to advanced, open economies in general. The Stylised model, like CGETAX, allows for imperfect competition and models the disincentive effects of taxes on labour supply, the capital-to-labour ratio, and the choice between present and future consumption. Of the major taxes, company income tax is found to be least efficient, with a marginal excess burden of 139 cents per additional dollar of tax revenue. For open economies the literature finds that company tax is among the most inefficient of taxes because it suppresses labour supply and the capital to labour ratio and leads to profit shifting to lower taxed jurisdictions. For Australia, company tax is even more inefficient because of its above-normal company tax rate and the erosion of the final revenue yield through the system of franking credits.

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Keywords: CGE, computable general equilibrium, oligopoly, Cournot Nash, tax efficiency, Australia

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Efficiency of the Tax System: a marginal excess burden analysis

Summary

Introduction

The total marginal burden on households from a government raising an additional dollar of revenue from a tax includes both the one dollar payment plus the marginal excess burden (MEB) from the inefficient activities undertaken in reaction to the tax increase. The MEB, which is borne by consumers, arises from the disincentive effects of taxes on labour supply, investment, saving and other economic decisions.

Consumers benefit when the tax system places less reliance on taxes with high MEBs and more reliance on taxes with low MEBs. For an optimally efficient tax system, the tax mix would be adjusted in this way until MEBs are equated across taxes to maximise consumer welfare. However, the equity of the tax system also needs to be taken into account, so a balanced approach involves considering both efficiency and equity.

This paper provides an analysis of the following federal, state and local taxes.

- 1) company tax
- 2) personal and superannuation income tax
- 3) GST
- 4) payroll tax
- 5) stamp duty on conveyances
- 6) municipal rates and land tax
- 7) insurance taxes

Theoretical Analysis

A theoretical MEB analysis for the major types of taxes is undertaken first. This shows the major economic principles and key parameters involved in estimating MEBs. The first source of inefficiency from the tax system is when the final economic incidence of a tax falls on labour, resulting in a disincentive to supply labour.

Personal income tax and GST both reduce the purchasing power obtained from an additional hour of work. Personal income tax does this by reducing take-home pay, while GST does this raising the cost of living. Hence both taxes fall on labour and act as a disincentive to supply it.

While the legal incidence for payroll tax falls on employers, its final economic incidence is similar to personal income tax on labour income. This is because both taxes add to the same

tax wedge between the post-tax wage incomes of employees and the wage costs faced by employers.

Turning to the economic incidence of company tax, foreign investors have a wide choice of countries in which to invest. Hence, it is widely assumed that local company tax simply adds to their hurdle rate of return for investing in that country. This means that, in the long run in a small open economy such as Australia, local company tax does not squeeze post-tax returns to foreign investors but instead squeezes local real wages. This is true to the extent that company tax applies to normal returns to capital.

Thus, in the long run, the economic incidence of the major taxes –personal income tax, GST, payroll tax and company tax – falls mainly on labour, resulting in a disincentive to supply it. The associated MEBs for each of these taxes are shown to depend on the same two general factors:

- the total marginal tax burden on labour, after all four taxes are taken into account, which is around 40 per cent; and
- the sensitivity of labour supply to changes in this tax burden. This is measured by the compensated elasticity of the labour supply with respect to the real marginal post-tax wage faced by labour. This elasticity is set to 0.4 based on the widely-cited study of Gruber and Saez (2002).

The MEBs of individual taxes also vary with other factors that are specific to each tax and are discussed in more detail below. These specific factors include the progressivity/regressivity of the tax change under consideration and the extent to which the incidence of the tax falls partly, rather than fully, on labour.

The second source of inefficiency from the tax system is the investment disincentive effect. Company tax not only has a labour supply disincentive effect as just outlined, but in addition it raises the hurdle rate of return for investing in a country leading to an investment disincentive effect. This reduces the capital-labour ratio and productivity. This combination of two disincentive effects leads to the general international finding that company tax is more inefficient than the other major taxes i.e. has a higher MEB.

The elevation in the company tax MEB from the investment disincentive effect depends on:

- the effective rate of company tax, which is relatively high in Australia; and
- the elasticity of substitution between capital and labour, which is set at 0.7 to 0.9 based on Gunning et al. (2008).

The third major disincentive effect from the tax system is the saving disincentive effect. Taxation of asset income within both the personal income tax and superannuation income tax systems creates a disincentive to save. This blunts the benefit that consumers would otherwise receive from timing their consumption in line with their needs rather than in line

with the fluctuations in their income. The MEB from taxing asset income is found to depend on three factors:

- the total burden of taxation on asset income, which is relatively low because of tax concessions for housing, superannuation and (through franking credits) dividends;
- the elasticity of substitution between present and future consumption, which is set at 0.25 after taking into account the findings of Gunning et al. (2008) and the partial control of saving behaviour through Australia's compulsory superannuation system; and
- the narrowness of asset income as a tax base: this tax influences the timing of consumption, but asset income only funds a relatively small share of consumption expenditure.

The Economic Modelling Approach

The MEBs of the taxes were simulated using the CGETAX model.

Previously, a Treasury working paper of Cao et al. (2015) used the Treasury version of the Independent Economics Computable General Equilibrium (IE CGE) model to assess the efficiency of certain taxes. That model includes the following features for modelling tax inefficiencies:

- tax disincentives to supply labour;
- the concessional tax treatments of housing and dividends;
- tax disincentives to investment;
- profit shifting;
- 114 industries; and
- the snapshot of the economy provided by the ABS input-output tables for 2007-08.

CGETAX incorporates all of those features as well as the following additional features:

- tax disincentives to save;
- the progressive nature of the personal income tax system;
- the concessional tax treatment of superannuation;
- an expansion to 278 industries so that more narrowly-based taxes can be modelled;
- oligopoly power in industries with persistently above-normal rates of return on capital for greater realism; and
- the latest detailed snapshot of the economy from the ABS input-output tables for 2012-13.

This means that the IE CGE model can reasonably be used to model inefficiencies from certain taxes, but at the same time CGETAX covers a wider range of inefficiencies and taxes and has a more up-to-date database.

Marginal Excess Burdens

The MEBs of the taxes were simulated using CGETAX. The results are summarised in Table A. As noted above, the MEB measures the consumer loss per dollar of improvement in the government budget from a small tax rise, over and above the amount of revenue that is raised. For example, Table A shows that there is an MEB of 139 cents per additional dollar of revenue from having a company tax rate of 30 per cent rather than 25 per cent.

MEBs can similarly be used to assess the impact on consumers of a tax cut. In particular, the above MEB also means that there is a consumer benefit of 139 cents per dollar of tax cut from reducing the company tax rate from 30 to 25 per cent, as recently proposed. This reflects the improvement in economic incentives from the tax cut and is in addition to the consumer benefit from the additional dollar of income. Thus, the benefit-to-cost ratio for consumers from this tax cut is 2.39. By comparison, the MEB for a labour income levy of 33 cents per dollar of additional revenue means that the benefit-to-cost ratio for consumers from a labour income tax cut (that is designed on a fixed proportion of income basis) is 1.33.

Turning to the pattern and economic interpretation of the MEBs showing in Table A, the following points can be made.

- A labour income levy has an MEB of 33 cents per dollar of revenue, reflecting the labour supply disincentive effect.
- An asset income levy has an MEB of 18 cents per dollar of revenue, reflecting the saving disincentive effect. The MEB for a reduction in franking credits is similar at 16 cents per additional dollar of revenue and also reflects the saving disincentive effect.
- The asset income levy has a lower MEB than the labour income levy because of the tax concessions available for asset income, including for housing, superannuation and dividends. In the absence of these concessions, the asset income levy would have a higher MEB than the labour income levy.
- A levy on all personal income has an MEB of 31 cents per dollar of additional revenue and can be interpreted as a weighted average of the two separate MEBs for labour income tax and asset income tax.
- The MEB from varying personal income tax depends on the regressivity/progressivity of the change to the rate scale. By definition a more progressive change lifts marginal tax rates more than average tax rates. This results in a higher MEB because marginal tax rates drive disincentive effects while average tax rates drive the revenue yield. Thus, the MEB rises from 18 cents for bracket creep to 31 cents for an income levy to 41 cents for a tax surcharge.
- Personal income tax is progressive by design, with the aim of improving equity. Ideally, the degree of progressivity in the personal income tax scale would be set by balancing the equity benefit from more progressivity against the efficiency cost.
- Raising GST has a relatively low MEB of 18 cents per additional dollar of revenue, compared to 33 cents for the labour income levy. This is mainly because only 71 per cent of the consumption expenditure tax base for GST is funded from after-tax labour

incomes, limiting the labour supply disincentive effect. The remainder is funded from unsaved asset incomes and government transfer payments.

- Broadening the GST to include fresh food has a lower MEB of 10 cents per additional dollar of revenue. This base broadening makes GST more efficient by removing a disincentive to consume served and processed food rather than fresh food.
- Raising the rate of payroll tax has an MEB of 37 cents per additional dollar of revenue, which is higher than the MEB for a labour income levy of 33 cents per additional dollar of revenue. This is because the small business exemption from payroll tax creates a disincentive for employment in large firms relative to small firms.
- Similarly, broadening the base of payroll tax by reducing the small business threshold reduces the associated inefficiency, leading to a lower MEB of 24 cents per additional dollar of revenue.
- Company income tax has a high MEB of 139 cents per additional dollar of revenue, when considering the difference between company tax rates of 25 and 30 per cent. This compares to the MEBs for the other major taxes – personal income tax and GST – of under 50 cents. This makes reducing the company tax rate to 25 per cent the top priority for tax reform in Australia.
- This high MEB partly reflects the labour supply and investment disincentive effects from company tax discussed previously. Adding to this inefficiency from company tax is profit shifting to lower tax jurisdictions, which wastes resources on tax avoidance and erodes the revenue base.
- One reason that company tax has a particularly high MEB in Australia is the franking credits system. It raises the MEB from company tax from 85 to 139 cents per dollar of additional revenue by refunding around 30 per cent of company tax collections, eroding the government revenue yield.
- Another reason that company tax has a particularly high MEB in Australia is our high rate of tax. Devereux et al. (2016) project that by 2020 Australia's international competitiveness for company tax will place it only 15th out of the G20 countries, despite Australia's relatively high reliance on foreign investment. Cutting the company tax rate from 30 to 25 cent would lower the MEB from 139 to 96 cents per dollar of revenue, as seen in Table A.
- One factor mitigating the inefficiency from company tax is foreign tax credits for Australian company tax, although these tax credits only apply to around five per cent of Australian company tax collections and are fully taken into account in the modelling.
- Another mitigating factor is when company tax applies to economic rents, including oligopoly rents, although these rents can always be taxed more efficiently with rent taxes than with company tax. This is also fully taken into account in the modelling.
- As a tax on ownership transfer costs, conveyancing duty has a narrow base and a high effective tax rate, which both make it a highly inefficient tax. The stocks of residential and commercial buildings are not used efficiently because of the tax disincentive against a change of ownership when circumstances change. The MEBs are 87 cents in

the dollar of additional revenue for residential conveyances and 196 cents for commercial conveyances.

- Shifting from land tax (MEB of 48 cents in the dollar) to the more broadly-based municipal rates (MEB of 23 cents in the dollar) would improve the efficiency of land taxation. A further efficiency gain would be available by removing discrimination in municipal rates between land uses.
- Once it is taken into account that the true economic base for insurance taxes is the premium net of expected benefit, insurance taxes are seen to be levied at high effective rates on narrow bases, particularly in the cases of motor vehicle insurance and general insurance. This gives them a high MEB of 58 cents per additional dollar of tax revenue.

Table A Marginal Excess Burdens of Taxes (per cent of net revenue)

Tax Change	MEB
Company income tax:	
CIT from 25% to 30%	139%
CIT from 20% to 25%	96%
CIT from 15% to 20%	68%
Personal and super income taxes:	
PIT surcharge	41%
PIT income levy	31%
PIT bracket creep	18%
labour income levy	33%
asset income levy	18%
reduce franking credits	16%
GST:	
raise rate	18%
broaden base to fresh food	10%
Payroll Tax:	
raise rate	37%
reduce threshold	24%
Property taxes:	
municipal rates	23%
land tax	48%
conveyancing duty: residential	87%
conveyancing duty: commercial	196%
Insurance taxes	58%

1 Introduction

This paper uses economy-wide modelling to assess the economic efficiency or marginal excess burdens of taxes.

The marginal excess burden (MEB) refers to the efficiency cost of raising an additional dollar of revenue from a tax. This efficiency cost is over and above the amount of revenue that is raised and arises because taxes may have disincentive effects, including on labour supply, investment and saving. Such efficiency costs are borne by consumers.

A hypothetical “lump sum” tax by definition does not affect economic behaviour and so has an MEB of zero. However, most taxes have disincentive effects that lead to a positive MEB. One guide to the average magnitude of MEBs is that the US Office of Budget and Management has directed that US government agencies assume an average MEB of 25 cents per dollar when conducting cost-benefit analyses of spending programs. This implies that for a spending program to be worthwhile, every four dollars of budget cost must provide at least five dollars of public benefit, so that the marginal excess burden of 25 cents in the dollar of tax revenue, or one dollar in four dollars, is covered.

Consumers benefit when the tax system places less reliance on taxes with high MEBs and more reliance on taxes with low MEBs. For an optimally efficient tax system, the tax mix would be adjusted in this way until MEBs are equated across taxes. However, the equity of the tax system also needs to be taken into account, so a balanced approach involves considering both efficiency and equity.

This paper covers the following federal, state and local taxes.

- company tax
- personal income tax: with sensitivity to progressivity of the rate scale adjustment
- personal and super income tax: separately for labour and asset income components
- GST: separately for raising the rate and broadening the base to include fresh food
- payroll tax: separately for raising the rate and broadening the base by reducing the threshold
- stamp duty on conveyances: separately for residential and commercial
- municipal rates: compared to land tax
- insurance taxes

Computable General Equilibrium (CGE) models have been used to analyse the economic efficiency of tax policy since the seminal work for the USA by Ballard, Shoven and Whalley (1985). For Australia, the author of this paper led a CGE model project (KPMG Econtech, 2010) to assess the efficiency of the major Australian taxes for the Henry Tax Review (AFTSR, 2009).

The focus then turned to company tax. The author worked in collaboration with The Treasury to develop the Independent CGE model to specifically assess the economic effects

of company tax for the Business Tax Working Group (Australian Government, 2012). As part of the recent tax review process, The Treasury further developed the Independent CGE model to allow an analysis of the MEBs for personal income tax, GST and stamp duty on conveyances, in addition to company tax (Cao et al., 2015).

Separate to that Treasury model development work, Independent Economics has undertaken a larger scale re-development of the Independent CGE model to allow a more comprehensive analysis of the MEBs of different taxes. Now known as CGETAX, this model includes more in-depth treatments of personal income tax and GST, which allow a wider range of policy variations to be modelled. CGETAX also extends the modelling to cover payroll tax, municipal rates, land tax and insurance tax.

To support this additional tax detail, the number of industries has been expanded from 114 to 278. In another development, the detailed economic snapshot used as the main database has been advanced from 2007-08 to 2012-13, the latest available input-output tables from the ABS. Finally, the assumption of perfect competition has been relaxed to allow for oligopoly power in industries with persistently high profitability. These developments make CGETAX the leading model for assessing the efficiency of the Australian tax system.

It is important that an MEB analysis is transparent and based on widely-accepted economic principles of tax analysis. Thus, section 2 of this paper presents general MEB formulas for the main economic types of taxes – taxes on labour income, asset income, consumption expenditure and corporate income. These formulas are derived from a standard, theoretical model of an open economy that is also a Stylised version of CGETAX.

Section 3 of this paper provides an overview of CGETAX, emphasising where it extends the Stylised model. It also discusses the values for the key economic parameters that influence the estimates of the MEBs.

The MEB estimates are presented in section 4. This distinguishes the inefficient taxes with high MEBs from the efficient taxes with low MEBs, and explains the reasons for the differences.

Section 5 subjects the MEB estimates to sensitivity analysis. It analyses how MEBs depend on the assumed values of key parameters, the existing tax burden, and allowances for imperfect competition. The sensitivity analysis draws on both the Stylised model and the full CGETAX model.

An appendix sets out the Stylised version of CGETAX in full.

2 MEB formulas

It is important that an MEB analysis is transparent and based on widely-accepted economic principles of tax analysis. Thus, this section presents general MEB formulas for the main economic types of taxes – taxes on labour income, asset income, consumption expenditure and corporate income. These formulas are derived from a standard, theoretical model of an open economy such as Australia. This theoretical model is also a Stylised version of CGETAX.

The Stylised model covers personal income tax and superannuation income tax as they apply to labour income and asset income, corporate income tax, payroll tax and consumption tax. It captures the effects of these taxes on labour supply, the capital-labour ratio and the choice between present and future consumption. It does this while allowing for imperfect competition, with perfect competition as a special case.

CGETAX incorporates all of structure of the Stylised model, making the Stylised model a useful aid in understanding CGETAX. At the same time, as a large scale model, CGETAX is far more developed than the Stylised model. These other features of CGETAX are discussed in section 3.

The full details of the Stylised model and the derivations of MEB formulas from it are set out in the appendix. This section is concerned with the main economic results. First, the core of the Stylised model is outlined, including the roles of taxes on labour, capital and consumption. Second, the MEB formula for each of these taxes is presented and interpreted. Finally, the analysis is extended to cover the taxation of asset income and its MEB.

Stylised Model

In the Stylised model, a representative firm produces output using capital and labour under constant returns to scale. This firm is an oligopolist that determines price by applying a mark-up factor to marginal cost. This assumption for the form of oligopoly has the advantage that perfect competition can be allowed for as a special case, with a mark-up factor of one. It is the most common approach to oligopoly in CGE models (Roson, 2006). The mark-up factor is estimated from industry data on costs and profits and an assumed normal rate of return on capital.

In modelling domestic investment, the small open economy assumption is made. Specifically, with foreign investors having a wide choice of countries to invest in, company tax becomes a cost that adds to the hurdle rate of return for investing in a country. A higher company tax rate will therefore reduce investment in a country, leading to a lower capital-to-labour ratio.

In modelling labour supply, a representative household chooses a utility-maximising combination of consumption and leisure, known as full consumption. This means that labour supply will depend positively on the real, marginal post-tax wage faced by labour. Increases

in taxes that fall on labour will reduce this real wage and hence act as a disincentive to supply labour.

Saving behaviour is modelled by considering the choice of the representative household between present and future full consumption in the presence of a tax on asset income. A higher rate of tax on asset income will cause the representative household to increase current full consumption at the expense of future full consumption.

Marginal Excess Burdens (MEBs)

The total marginal burden on households from a government raising an additional dollar of revenue from a tax includes both the one dollar payment plus the marginal excess burden (MEB) from the inefficient activities undertaken in reaction to the tax increase. The MEB arises from the disincentive effects of taxes on labour supply, investment, saving and other economic decisions. These labour supply, investment and saving disincentive effects were introduced above.

The MEB of a tax can be defined more precisely as the consumer loss per dollar of improvement in the government budget from a small tax rise. The gain to the government budget is returned to the consumer as a lump-sum transfer (“transfer”), so the consumer loss that is measured only reflects the disincentive or substitution effects from the tax rise, not the income effect. The assumption of a lump-sum transfer to re-balance the budget is a device to allow the efficiency of each tax to be compared on the same footing; it is not intended as a realistic assumption about how government budgets are adjusted in practice.

The labour supply, investment and saving disincentive effects of specific taxes are now considered in turn, beginning with the labour supply disincentive effect. This occurs when the final economic incidence of a tax falls on labour.

Personal income tax and GST both reduce the purchasing power obtained from an additional hour of work. Personal income tax does this by reducing take-home pay, while GST does this raising the cost of living. Hence both taxes fall on labour and act as a disincentive to supply it. However, GST has a weaker labour supply disincentive effect because its tax base of consumption expenditure is partly funded from non-labour income. That is, GST acts partly as tax on labour income, and partly as a tax on non-labour income.

While the legal incidence for payroll tax falls on employers, its final economic incidence is similar to personal income tax on labour income. This is because both taxes add to the same tax wedge between the post-tax wage incomes of employees and the wage costs faced by employers.

Turning to company tax, as noted above, foreign investors have a wide choice of countries to invest in. In their investment decisions, company tax becomes a cost that adds to their hurdle rate of return for investing in a country such as Australia. Thus, in the long run, company tax

does not squeeze post-tax returns to foreign investors, but instead squeezes local real wages, to the extent that company tax applies to normal returns to capital. Therefore in considering the total tax burden on labour, company tax needs to be taken into account, alongside the more obvious taxes on labour.

Payroll tax and Labour Income Tax

In the Stylised model both payroll tax and labour income tax have the same MEBs. They both reduce consumer welfare in the same way by reducing the real after-tax wage received by labour, resulting in a disincentive to supply labour. Similarly, the contribution of both taxes to the government budget is tied to labour incomes. The appendix shows that the MEB for payroll tax and labour income tax can be written as follows.

$$meh(tl, tn) = \frac{\eta.tlab}{1-\eta.tlab} \quad [1]$$

Here $tlab$ is the comprehensive tax rate on labour income, when all taxes that ultimately fall on labour are taken into account. As indicated above, these labour taxes include company income tax, labour income tax, payroll tax and part of consumption tax. In calculating the comprehensive tax rate on labour income, the burden of these taxes is expressed relative to the tax base of post-tax labour income.

Further, η , measures the responsiveness of the labour supply to the real post-tax wage faced by labour. This responsiveness is measured by the compensated labour supply elasticity.

The MEB for payroll tax and labour income tax arises purely from the disincentive effect of these two taxes on the labour supply. As can be seen from equation [1], the magnitude of this MEB depends on the two factors, η and $tlab$, which enter symmetrically and are now considered in turn.

First, the MEB depends on the size of the existing tax burden on the labour market, as measured by $tlab$. The larger the existing labour market tax burden, the greater the welfare loss from raising an additional dollar of revenue from payroll tax or labour income tax. A large tax burden creates a wide gap between the marginal value of an additional unit of labour in production and the marginal value of an additional unit of leisure time.

Second, the MEB depends on the responsiveness of the labour supply to the worker real post-tax wage, as measured by the compensated labour supply elasticity η . The higher is this elasticity, the greater the welfare loss from raising an additional dollar of revenue from payroll tax or labour income tax.

In CGETAX, the compensated elasticity is based on the widely-cited study of Gruber and Sayers (2002) who find an “elasticity of taxable income” of 0.4. This choice of value is discussed further in section 3.

Consumption Tax

Consumption tax has a positive MEB, but it is lower than for payroll tax and labour income tax. This is because the tax base, consumption expenditure, is funded from two different sources – labour income (71 per cent) and non-labour income (29 per cent). The appendix shows that the MEB formula for consumption tax is as follows.

$$meh(tc) = \frac{\eta.tlabadj}{1-\eta.tlabadj} \quad [2]$$

This takes the same form as the MEB for payroll and labour income of equation [1]. The difference is that the MEB for consumption tax depends on an adjusted form of the comprehensive tax rate on labour income, $tlabadj$. The adjustment is that the labour tax burden is expressed as a percentage of labour income plus non-labour income, rather than as a percentage of labour income alone. This gives a lower tax rate and therefore a lower MEB.

Company Income Tax

The second source of inefficiency from the tax system is the investment disincentive effect. Company tax not only has a labour supply disincentive effect as just outlined, but in addition it raises the hurdle rate of return for investing in a country leading to an investment disincentive effect. This reduces the capital-labour ratio and productivity. This combination of two disincentive effects leads to the general international finding that company tax is more inefficient than the other major taxes i.e. has a higher MEB.

In considering the MEB of company tax, a distinction can be used between company tax raised from normal returns to capital tax and company tax raised from oligopoly rents. Consider first the MEB for company tax in the absence of oligopoly rents. In that case, company tax becomes a pure tax on capital. The appendix shows that the MEB for a capital tax is as follows.

$$meh(tk_r) = \frac{\eta.tlab + \frac{\sigma}{\alpha}.tke}{1 - \eta.tlab - \frac{\sigma}{\alpha}.tke} \quad [3]$$

Comparing this MEB for a capital tax with the MEB for a labour tax given by equation [1], the MEB for a capital tax is seen to be higher. Both taxes have the same disincentive effect on labour supply. This is because in both cases a tax rise is fully passed on as a fall in the worker real post-tax wage.

The difference between a capital tax and a labour tax is that the capital tax also has a disincentive effect on the capital-to-labour ratio. An increase in the rate of capital tax raises the user cost of capital, inducing a lower capital-to-labour ratio. In equation [3] for the MEB for capital tax, this capital-labour ratio disincentive effect is captured by the following term,

$$\frac{\sigma}{\alpha}.tke$$

where tk_e is the effective tax rate on capital, which scales down the statutory tax rate to take into account that depreciation is excluded from the tax base.

The strength of the capital-labour ratio disincentive effect from a rise in capital tax is seen to depend on two factors. First, it depends on the effective tax rate on capital, tk_e . The higher this existing effective tax rate, the higher the consumer loss from raising an additional dollar of revenue from capital tax.

Second, it depends on the elasticity of the capital-labour ratio with respect to the cost of capital. This in turn equals the elasticity of substitution between labour and capital σ , divided by labour's share of income α . Thus, the elasticity of factor substitution drives the strength of the response of the capital-to-labour ratio to a company tax cut. Based on the literature survey of Gunning et al. (2008), elasticities of substitution between labour and capital in CGETAX range from 0.7 to 0.9. This choice of values is discussed further in section 3.

Now consider the MEB for a hypothetical tax on oligopoly rents. Such a tax does not alter the cost of capital. Its MEB formula is derived in the appendix as the following.

$$meb(tk_{ro}) = \frac{-kf}{k} \quad [4]$$

An increase in tax on oligopoly rents has an MEB equal to the negative of the share of the capital stock owned by foreign investors. Higher tax on oligopoly rents has no behavioural effects on either foreign or domestic investors. However, the additional tax on foreign investors represents a gain in national income. Thus, there is a gain in consumer welfare equal to the share of foreign-owned capital in the total capital stock. This makes it highly efficient to tax oligopoly rents.

The overall MEB for company tax is approximately equal to a weighted average of the MEBs on the capital and oligopoly rent components of the company tax base.

$$meb(tk) = \frac{r}{rm} \cdot meb(tk_r) + \frac{ro}{rm} \cdot meb(tk_{ro}) \quad [5]$$

This is an approximation because there is also an interaction effect between the taxation of normal returns and oligopoly rents to take into account, as explained in the appendix.

This analysis indicates that capital tax is highly inefficient while an oligopoly rent tax is highly efficient. Company tax mixes these two taxes together. The CGETAX model, but not the Stylised model, also incorporates many other aspects of the Australian company tax system. These include profit shifting by MNCs and franking credits, which both make company tax even more inefficient, as well the presence in very limited circumstances of foreign tax credits, which make company tax more efficient. These complications are discussed further in section 3 and are taken into account in the CGETAX MEB results presented in section 4.

The third major disincentive effect from the tax system is the saving disincentive effect. Taxation of asset income within both the personal income tax and superannuation income tax systems creates a disincentive to save. This blunts the benefit that consumers would otherwise receive from timing their consumption in line with their needs rather than in line with the fluctuations in their income. In the appendix, the MEB from taxing asset income is derived to be the following.

$$meb(ta) = \frac{\sigma.t.a.\frac{rm}{(1-ta).rm-gr}}{\frac{(rm-gr).kd}{M} - \sigma.t.a.\frac{rm}{rm-gr}} \quad [6]$$

This mainly depends on three factors:

- the overall tax rate on asset income, ta , which is relatively low because of tax concessions for housing, superannuation and (through franking credits) dividends;
- the elasticity of substitution between present and future consumption, which is set at 0.25 after taking into account the findings of Gunning et al. (2008) and the partial control of saving behaviour through Australia's compulsory superannuation system; and
- the narrowness of asset income as a tax base: this tax influences the timing of full consumption, but asset income only funds a relatively small share of full consumption expenditure given by $\frac{(rm-gr).kd}{M}$. This makes asset income tax potentially an inefficient tax unless applied at a suitably low rate.

3 The Economic Modelling Approach

The Stylised model of section 2 and the appendix provides general insights into the efficiency of the major types of taxes. The Stylised model is also a useful aid in understanding CGETAX, because CGETAX incorporates all of structure of the Stylised model.

At the same time, as a large scale model, CGETAX is far more developed than the Stylised model. CGETAX covers a fuller range of taxes, allows for additional complexities in the designs of particular taxes and deals more comprehensively with behavioural responses. These features of CGETAX are now discussed. This discussion completes the economic backdrop to the estimates of MEBs presented in section 4.

Computable General Equilibrium (CGE) models such as CGETAX model the interaction of the household, business, government and foreign sectors in economic markets. The household and business sectors aim to maximise their utility and profit respectively. Prices adjust in each market until supply is balanced with demand.

When an economic activity is taxed heavily, economic returns are reduced, which can lead to a tax-driven, economically inefficient shift away from that activity and towards other less-heavily taxed activities. The extent of such shifts and associated economic losses depends on

the substitutability between activities, as measured by various elasticities. CGE models provide a means of quantifying these shifts and losses.

CGETAX is a long run models, meaning that its results refer to the ongoing effects on the economy after it has fully adjusted to economic shocks. This is appropriate for policy analysis, because government policy options should be assessed primarily on the basis of their lasting impacts, although it is also appropriate to take adjustment costs into consideration.

This section begins by describing previous CGE modelling of tax policy. It then describes how, in CGETAX, taxes influence the behaviour of the household, before moving on to the effects of taxes on the behaviour of businesses. The values of the key elasticities that determine the magnitudes of these behavioural responses are then discussed. Finally, it explains how CGETAX is used to estimate the MEBs used to assess the economic efficiency of different taxes.

Previous Work

Computable General Equilibrium (CGE) models have been used to analyse the economic efficiency of tax systems since the seminal work for the USA by Ballard, Shoven and Whalley (1985). They estimated marginal excess burdens (MEBs) for the major US taxes.

The MEB shows the consumer loss per dollar of improvement in the government budget from a small tax rise. This loss is measured over and above the amount of the revenue that is raised¹. Thus, the MEB provides a pure measure of the costs to consumers of disincentive effects from a tax. These disincentive effects may include disincentives to work, save or invest, or to the patterns in the same areas. More narrowly-based taxes may also distort more specific economic choices e.g. between different alcoholic beverages.

Ballard et al. (1985) reached two major conclusions.

“There is growing evidence that MEBs may be in the range of 15 to 50 cents for an economy like that of the United States.” Such a wide range means that there is a large potential for consumers benefiting by the US Government relying more on taxes with low MEBs and less on taxes with high MEBs. In principle, tax efficiency would be optimised by shifting the tax burden in this way until MEBs are equalised across all taxes.

“We hope that the large estimates we report will contribute to ... a discussion of possibly modifying the cost-benefit criterion for public goods evaluation.” For example, if a government spending program is to be funded with a tax with a typical MEB of say 25 cents

¹ The income effect on consumers from raising revenue from them is neutralised by assuming the revenue is returned as a lump-sum transfer, leaving only the disincentive effects.

per dollar, each four dollars of program spending would need to provide consumers with benefits of at least five dollars for the program to be worthwhile. This is so the program covers the direct cost to taxpayers of \$4, plus the additional cost from disincentive effects of one dollar (or 25 cents per dollar of additional revenue).

Since that time, the author of this paper, Chris Murphy, has led three CGE projects to model the efficiency of various aspects of the Australian tax system.

MM900 modelling (KPMG Econtech, 2010) was commissioned by The Treasury for the Australia's Future Tax System Review ("Henry Tax Review"). It focussed mainly on work disincentives and the inefficiencies from narrowly-based taxes. The resulting estimates of MEBs were included in the Henry Tax Review report (AFTSR, 2009). The Treasury contributed important ideas to the development of MM900.

IE CGE modelling (Australian Government, 2012) was commissioned by The Treasury for the Business Tax Working Group (BTWG) and concentrated on detailed modelling of investment disincentive effects. In particular, the modelling represented many of the features of the company tax system, and the linkages from those features to investment decisions and government revenue. This led to improved estimates of the MEB for company tax.

Treasury contributed important ideas to the development of IE CGE and has continued to use this model under licence. As part of the recent tax review process, The Treasury further developed the model to allow an analysis of the MEBs for personal income tax, GST and stamp duty on conveyances, in addition to company tax (Cao et al., 2015).

Separate to that Treasury model development work, in 2014 and 2015 IE further developed its version of the model so that it covered the disincentive effects captured in both of the previous modelling exercises (MM900 and IE CGE). The resulting IE Extended CGE model therefore covered work and investment disincentive effects, as well as the inefficiencies from narrowly-based taxes.

Modelling the narrowly-based taxes, such as those on different forms of alcohol and insurance, was facilitated by expanding the number of industries from 114 to around 280. For example, this involves subdividing the original alcohol and tobacco industry so that the inefficiencies from taxing beer, wine and spirits differently can be modelled. It also involves subdividing the insurance and superannuation industry so that the inefficiencies from heavily taxing general insurance can be modelled robustly.

The IE Extended CGE model also includes a more in-depth treatment of personal income tax and GST. This distinguishes between average and marginal rates of personal income tax, and allows for differences in the degree of substitutability between different consumer goods and services for modelling changes to the coverage of GST.

In November 2015 The Treasury commissioned IE to undertake modelling to support the recent tax review process. As part of this, saving disincentive effects were introduced to the IE Extended CGE model to further enhance the modelling of personal income tax and to allow modelling of superannuation income tax. Payroll tax was also modelled, allowing for the behavioural effects of the small business exemption, and the modelling of several other taxes was also enhanced. The modelling of property taxation was also upgraded to distinguish land tax, municipal rates and stamp duty on conveyances.

The model was also updated for the latest ABS input-output tables, which refer to 2012-13. In another significant development, the assumption of perfect competition was relaxed to allow for oligopoly power in industries with persistently high profitability. Given the focus of this model on tax, and the increased use of it in academic research as distinct from consulting work, the extended and updated model is now known simply as CGETAX.

Thus, CGETAX includes detailed modelling of tax-based work, saving and investment disincentive effects, as well as the disincentives from narrowly-based taxes. This allows the effects of the design of the tax system on economic efficiency to be assessed more comprehensively than with the previous models. Further, CGETAX has a fully up-to-date database and allows for imperfect competition. These developments make CGETAX the leading model for assessing the efficiency of the Australian tax system.

Table 3.1 summarises how the features on the CGE model have developed with each version, beginning with IE CGE, then Extended IE CGE and finally CGETAX.

Table 3.1: Development of Model: detail, taxes, behavioural responses and calibration

Feature	Original IE CGE Model	Extended IE CGE Model	CGETAX
<i>Detail</i>			
Industries	114	288	278
Types of labour	1	8	2 x 8
Types of capital	9	9	9
Location rents (land and minerals)	yes	yes	Yes
Oligopoly rents	no	no	Yes
<i>Taxes</i>			
personal income tax	average rate	marginal and average rates	marginal and average rates
superannuation income tax	NA	NA	contributions, earnings
Payroll tax	NA	NA	threshold and rate
Company income tax	historic cost depreciation, investment allowances, franking credits, foreign tax credits, interest deductibility, profit shifting, net foreign investment	historic cost depreciation, investment allowances, franking credits, foreign tax credits, interest deductibility, profit shifting with avoidance costs, net foreign investment	historic cost depreciation, investment allowances, franking credits, foreign tax credits, interest deductibility, profit shifting with avoidance costs, foreign investment in both directions
Externality taxes	NA	Beer, spirits, wine	Beer, spirits, wine, fuel, tobacco, gambling
GST	NA	Taxable/exempt/zero-rated	Taxable/exempt/zero-rated
Property taxes	generic land tax, conveyancing duty	generic land tax, conveyancing duty	Land tax, municipal rates, residential conveyancing duty, commercial conveyancing duty
Other specific taxes	NA	Import duty, insurance tax	Import duty, insurance tax, mining royalties, PRRT
<i>Behavioural responses / elasticities</i>			
present-future consumption (EIS)	NA (0)	NA (0)	0.25
labour supply (compensated)	0.4	0.4	0.4
within consumption	0.6	0.6 broad, 0.6-2.4 detailed	0.6 broad, 0.6-2.4 detailed
labour-capital	0.9 equipment, 0.5-0.7 structures	0.9 equipment, 0.5-0.7 structures	0.9 equipment, 0.5-0.7 structures
between occupations	NA	2	3
between taxed & untaxed labour	NA	NA	3
company tax base: semi-elasticity	-0.5	-0.5	-0.73
<i>Calibration</i>			
I-O Table	2007/08	2009/10	2012/13
Tax Revenue	2007/08	2013/14	2015/16

Note: PRRT is the petroleum resource rent tax

Some of the additional modelling of tax inefficiencies in the two newer models is based on new modelling of the behavioural responses of households and businesses to taxes. Those household and business behavioural responses to taxes in CGETAX are now discussed in turn.

Taxes and Household Behaviour

In CGETAX a single, structured utility function covers all aspects of household decision making. Such an integrated approach is necessary so that changes in consumer welfare due, for example, to changes in tax policy, can be measured in a fully consistent way. Household decision making is arranged in four tiers. The two top tiers are similar to the Stylised model.

In the top tier, a representative household chooses its time path for full consumption (inclusive of consumption of goods and services and leisure), and this determines its saving behaviour.

$$U = \left\{ \int_0^{\infty} e^{-\rho \cdot t} u(t)^{\varepsilon} \cdot p(t) dt \right\}^{1/\rho}$$

In particular, the representative, infinitely-lived household maximises discounted future utility U from a planned time path of full consumption $u(t)$. The size of the household or population is $p(t)$ and grows at the population growth rate of θ .

The representative household's choice between present and future full consumption is distorted by the tax on asset income at the marginal rate tam . This is reflected in the Euler equation for the optimal rate of growth in aggregate (as distinct from per capita) full consumption grc , which involves the elasticity of intertemporal substitution σt .

$$grc = \theta + \sigma t \cdot [(1 - tam) \cdot rm - \rho]$$

where:

$$\sigma t = 1/(1 - \varepsilon)$$

Thus, the value of the elasticity of intertemporal substitution, which is discussed later in this section, determines the strength of the saving disincentive effect when asset income is taxed ($tam > 0$).

Unlike the Stylised model, CGETAX distinguishes between average and marginal rates of income tax. This distinction is significant because saving decisions depend on marginal tax rates, as shown in the equation for grc , while government revenue depends on average tax rates.

In the second tier the representative household chooses the combination of leisure, $l(t)$, and consumption, $c(t)$, that maximises utility or the value of full consumption.

$$u(t) = u\left(\frac{c(t)}{p(t)}, \frac{l(t)}{p(t)}\right)$$

This combination will depend on the price of leisure relative to the price of consumption, p_c . The price of leisure is the income foregone by not working and hence equals the post-tax wage, $(1-tlm)w$, where tlm is the marginal tax rate for labour income and w is the wage. In the event of a change in their relative price, the optimal ratio of leisure to consumption can be shown to change as follows, where $\sigma(c,l)$ is the elasticity of substitution between leisure and consumption.

$$\frac{dl}{l} - \frac{dc}{c} = -\sigma(c,l) \cdot \left(\frac{d(1-tlm)}{(1-tlm)} + \frac{dw}{w} - \frac{dp_c}{p_c} \right)$$

Thus, the value of the elasticity of substitution between leisure and consumption, which is discussed later in this section, determines the strength of the work disincentive effect when labour income is taxed ($tlm > 0$). While labour supply decisions made at the intensive margin (i.e. hours worked in a year) depend on the marginal tax rate, decisions made at the extensive margin (i.e. whether to work in a year) depend on the average tax rate. To take this into account, the effective marginal tax rate used in the model, tlm , is constructed as a weighted average of the marginal and average tax rates.

Again, CGETAX improves on the Stylised model by distinguishing between average and marginal tax rates. This distinction is significant because labour supply decisions depend on marginal tax rates, as shown above, while government revenue depends on average tax rates.

The saving and work disincentive effects presented above are driven by taxation of asset and labour income. This involves taking into account both personal income tax and the more concessional superannuation taxes.

Within superannuation, a distinction is made between taxation of contributions, which is treated as a tax on labour income, and taxation of earnings, which is treated as a tax on asset income. The same distinction between taxing labour and asset income is made in modelling personal income tax.

Both personal income tax and superannuation tax are then considered together in calculating the overall level of taxation of labour income on the one hand, and asset income on the other. In finally assessing tax rates on asset incomes, franking credits are also taken into account.

For both labour and asset incomes a distinction is also made between average and marginal tax rates. Average tax rates drive revenue collections. Marginal tax rates drive tax-based disincentive effects, as discussed above. These marginal and average tax rates are built up

from separate analyses of the personal income tax and superannuation income tax systems, which are then weighted together.

One implication of the previous equation is that taxation can act as a work disincentive not only by reducing after-tax wages but also by increasing the price of consumption. Either way, taxation reduces the additional consumption that can be funded from an additional hour of work. Thus, both labour income and consumption taxes are said to form part of the labour market tax wedge developed in the Stylised model of section 2 and the appendix.

CGETAX separately models in detail a wide range of taxes on consumption including GST and specific taxes on fuel, tobacco, alcohol, gambling and insurance. Some of these specific taxes are sometimes described as “sin” taxes. Specifically, negative externalities associated with the consumption of fuel, tobacco, alcohol and gambling may justify specific taxes on these goods and services. As a first approximation, CGETAX assumes that this is the case. If instead these specific taxes were not explained in the model, their presence would distort the economic impacts of other taxes, including adding to work disincentives.

At the same time, GST, insurance taxes and some other consumption taxes are not associated with negative externalities. Therefore, they add to the work disincentive effects from the tax system by adding to the labour market tax wedge via the price of consumption, p_c . Their selective nature also means that they distort the pattern of consumer demand. This is captured in the final two tiers of the household decision making process.

In the third tier, households allocate their total consumption, c , across 19 broad categories of consumption, $cb(i)$, including food, alcoholic beverages, financial services etc. This allocation is governed by an elasticity of substitution, σ_c .

$$c = c(cb(1), \dots, cb(19))$$

In the fourth tier, households allocate their consumption between the goods and services that constitute each broad category, $cb(i)$.

$$cb(i) = cb(i)(cb(i, 1), \dots, cb(i, ni))$$

Within each broad category, the elasticity of substitution, $\sigma_c(i)$, can be set independently, introducing flexibility. This flexibility is useful in more robustly modelling the economic impacts of varying GST, insurance taxes and alcohol taxes.

For example, GST currently applies to processed and served food, but not fresh food. CGETAX is able to capture the resulting distortion to the pattern of food consumption by choosing an appropriate value for the elasticity of substitution within the food consumption category. This flexibility is not available when consumer demand is modelled in a single tier rather than in two tiers. The 2-tier approach provides the same advantage in modelling the

impacts of insurance taxes on the pattern of demand for financial services, and the uneven pattern of taxes on alcohol on the pattern of demand for alcoholic beverages.

Taxes and Industry Behaviour

Taxes also affect the behaviour of businesses.

As in CGE models generally, in each industry in CGETAX a representative business maximises profit subject to the constraints of technology. The nature of this process is similar for nearly all of the 278 industries in the model, so here it is described for a typical industry.

In a typical industry, the representative business maximises profit subject to the overall production technology depicted in Diagram 3.1. This is assumed to occur under constant returns to scale and either perfect or imperfect competition. Perfect competition is assumed in industries where rates of return on capital are not exceptionally high, after taking into account the contributions of fixed factors i.e. mineral resources and land.

Imperfect competition is assumed in some other industries, the main examples being the finance and telecommunications industries. The oligopolist determines price by applying a mark-up factor m to marginal cost. That mark-up represents oligopoly rents.

This assumption for the form of oligopoly has the advantages that perfect competition can be allowed for as a special case ($m=1$), and the assumption of constant returns to scale can be maintained. It is the most common approach to oligopoly in CGE models (Roson, 2006). It is consistent with a number of theories of oligopoly, including the well-known Cournot-Nash model and the more general conjectural variations model (Katz and Rosen, 1983 and Dung, 1993) and the mark-up strategy models of Grant and Quiggin (1994). These mark-up pricing models all have the common feature that they generate imperfect competition by assuming that the number of firms in an industry is fixed.

Profit maximisation gives rise to demands for four broad categories of primary inputs:

- minerals;
- labour;
- non-structure capital; and
- and structure services.

The effects of various taxes on these four categories of factor demand are now discussed.

Minerals are treated as a location-specific fixed factor that is present in certain mining and energy extraction industries. With fixed supplies, taxation of mining economic rents does not lead to behavioural responses or associated inefficiencies. Rather, the full incidence of the tax falls on the owners of the mineral resources. The only existing example of such a tax is the petroleum resource rent tax or PRRT.

Employment of labour is subject to payroll tax. This adds to the labour market tax wedge and the associated work disincentive effect in a similar way to the taxes on labour income and consumption. In addition, exemptions from payroll tax mean that only around 56 per cent of labour is taxed. This generates an inefficiency, inducing substitution from taxed labour to untaxed labour, as depicted in Diagram 3.2.

Diagram 3.1 Production in each industry

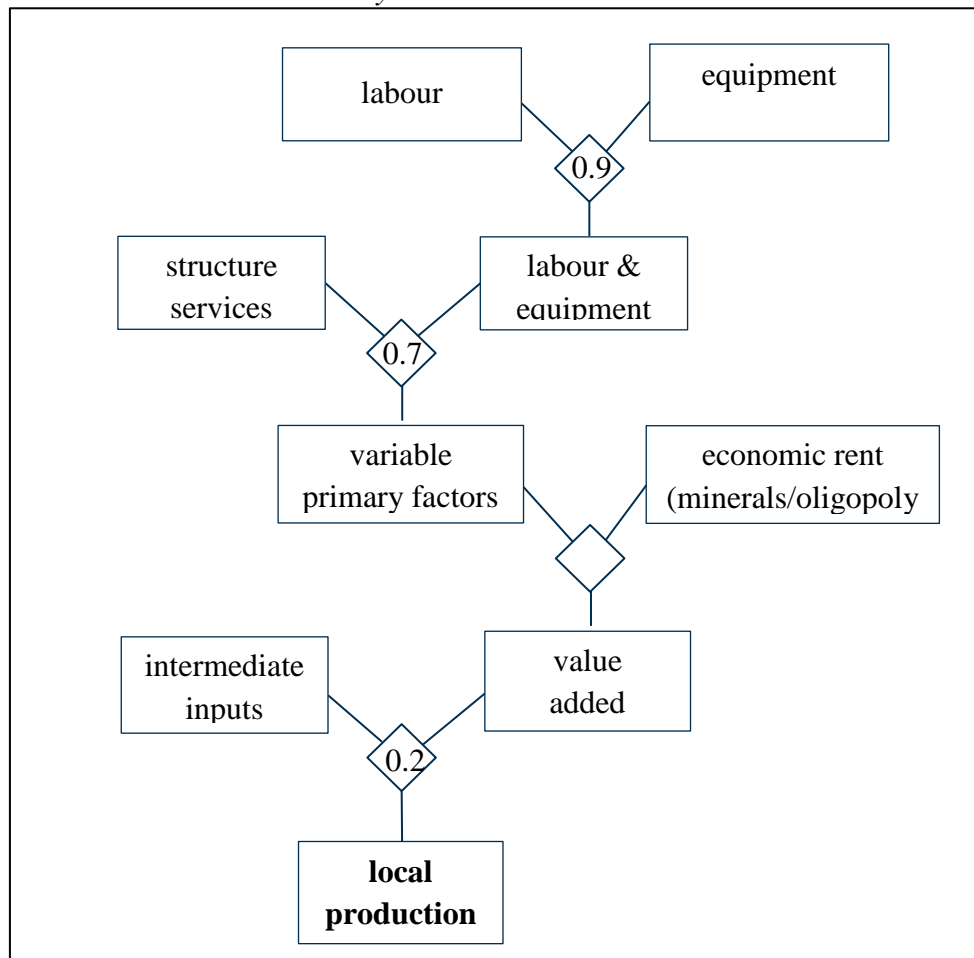
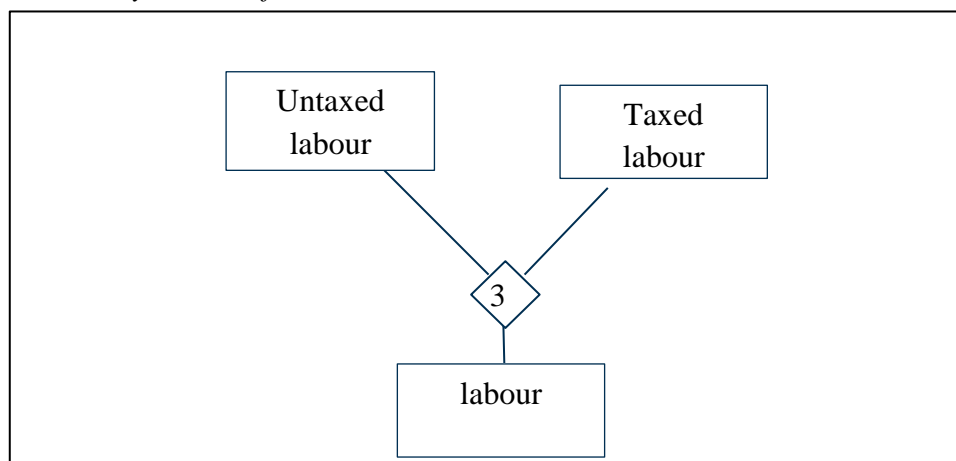


Diagram 3.2: Industry demand for labour - taxed and untaxed



This inefficiency is modelled by identifying, for each industry, the proportion of labour that would be exempt from tax, before substitution effects are taken into account. Untaxed labour includes the self-employed and labour in many not-for-profit organisations. Of the remaining 80 per cent of employment, only around 70 per cent is taxed due to the tax-free threshold. In 2012-13, the average threshold was \$772,000, which exempts around the first 11 employees in an organisation from payroll tax.

To model the effect of the tax-free threshold, for each industry a Lomax distribution of firm size was fitted for businesses with employees. This provided a good fit and follows Corbellini, Crosato, Ganugi and Mazzoli (2007) in applying the Lomax distribution to firm size. The cumulative density function for the Lomax distribution is as follows, where x is the number of employees in a firm.

$$F(x) = 1 - \left(1 + \frac{x}{\lambda}\right)^{-\alpha}$$

For firms with employees, the proportion of employment that is taxed, β , when the tax-free threshold is set at “th” employees, is derived to be the following.

$$\beta = \left(1 + \frac{th}{\lambda}\right)^{1-\alpha}$$

When simulating a change in the tax-free threshold, this formula is used to determine the change in the taxed share of employment, after also taking into account the self-employed and not-for-profit exemptions, and before taking the substitution effect from taxed to untaxed labour into account.

In each industry, for both taxed and untaxed labour, businesses choose a mix of labour from the eight single digit occupations, as depicted in Diagram 3.3. The mix is the same for both taxed and untaxed labour, because relative wage rates are the same, even though total wages are higher for taxed labour.

CGETAX distinguishes nine types of business capital, which are substitutable within the broader categories of equipment and structure services, as shown in Diagram 3.4. Capital is subject to company tax. The modelling of company tax was developed with The Treasury for the Business Tax Working Group.

Like the Stylised model of section 2 and the appendix, CGETAX makes the open economy assumption that the required rate of return on capital, post company tax, is determined on world capital markets. This implies that Australian company tax, to the extent that it applies to normal returns to capital, cannot lead to lower returns to foreign investors. Instead, it leads to a compensating increase in pre-tax rates of return achieved through lower real wages. Thus, the incidence of company tax is passed on from capital to labour. As discussed in section 2, this leads to the two textbook inefficiencies of company tax in an open economy.

Diagram 3.3: Industry demand for labour - occupations

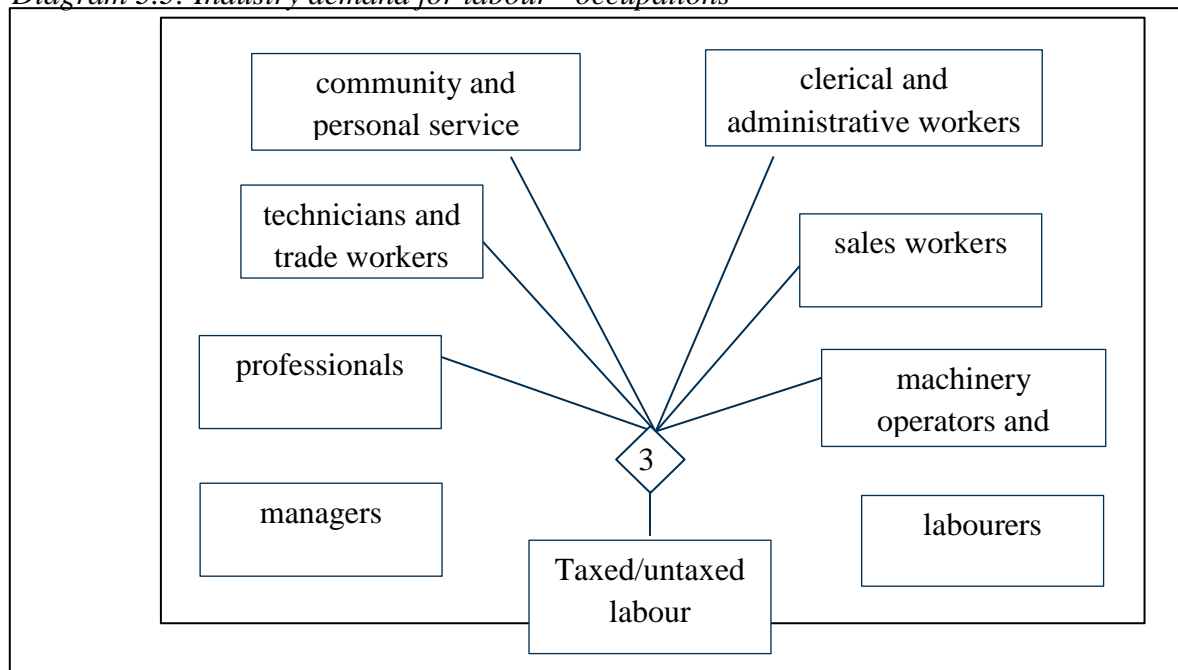
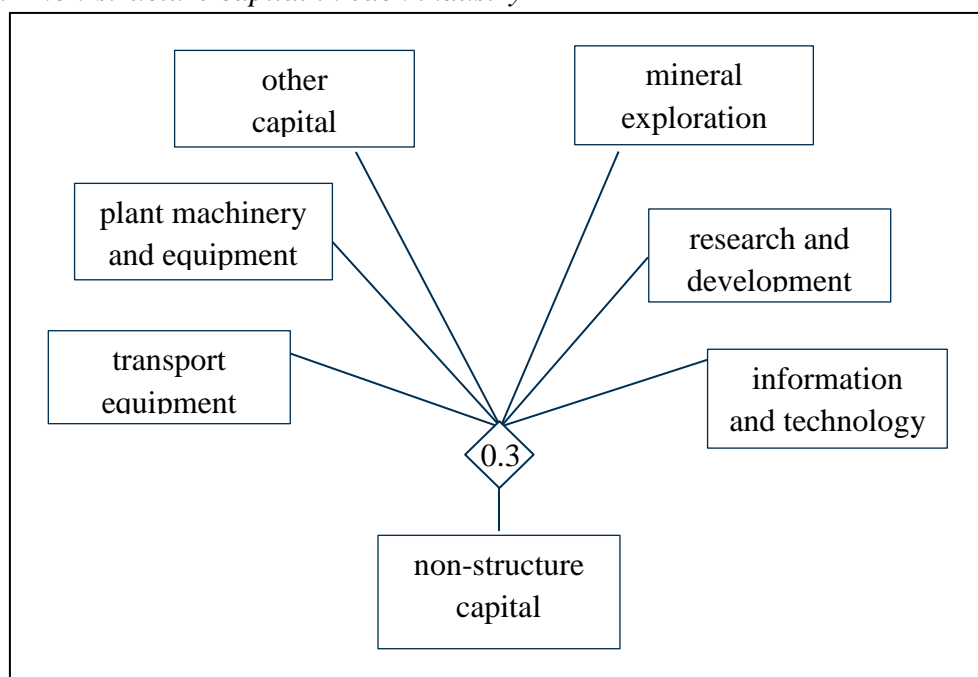


Diagram 3.4 Non-structure capital in each industry



- Company tax adds to the labour market tax wedge, adding to the work disincentive effect. This effect depends on a labour supply elasticity, as discussed above.
- Company tax raises the cost of capital, lowering the capital-labour ratio. This investment disincentive effect reduces productivity. The strength of this productivity effect depends on the elasticity of substitution between capital and labour.

On the other hand, to the extent that company tax applies to oligopoly rents that are over and above normal returns to capital, its incidence falls on shareholders. This was also analysed in detail in the Stylised model of section 2 and the appendix and applies in the same way in CGETAX. In CGETAX oligopoly rents are significant in the finance, telecommunications and beverage sectors.

Importantly, unlike the stylised model, CGETAX also allows for profit shifting. Following the approach of Devereux and de Mooij (2009), businesses are assumed to maximise post-tax profits, after assuming that the costs of profit shifting to a tax haven varies with the square of the difference between the national tax rate and the tax haven tax rate. This leads to a semi-elasticity of the national tax base with respect to the difference between the national tax rate and the tax haven tax rate. A lower national tax rate reduces the extent of profit shifting to the tax haven.

CGETAX also allows for six other aspects of the company tax system:

- franking credits, which are utilised with respect to around 30 per cent of company tax revenue;
- depreciation deductions are allowed using historic cost rather than replacement cost valuations;
- the immediate write-off of investment in mineral exploration and (with a loading) research and development – mineral exploration and research and development are distinguished as part of detailed modelling of different types of capital;
- debt deductibility;
- the ability of a very limited range of foreign investors to claim some tax credits in their home country for Australian company tax; and
- the inclusion of economic rents on fixed factors (land and minerals) in the company tax base.

The above features in CGETAX are inherited from the IE CGE modelling developed in collaboration with The Treasury for the BTWG. However, CGETAX makes six further improvements in the company tax modelling compared to the IE CGE modelling.

- CGETAX separately models foreign investment in Australia and Australian investment abroad, rather than modelling foreign investment in Australia in net terms. Hence it more fully captures the high level of foreign investment in Australian companies. This is important because foreign investment increases the efficiency of company tax to the extent that company tax applies to economic rents.

- As noted previously, CGETAX models saving disincentives. It therefore recognises that by reducing the net tax paid on asset income, franking credits reduce saving disincentives.
- As also noted previously, CGETAX recognises that high economic rents in certain sectors (e.g. finance, telecommunications) are due to imperfect competition rather than fixed factors of production. This is important because company tax and some other taxes lead to greater inefficiencies when economic rents are due to imperfect competition rather than fixed factors.
- CGETAX makes fully consistent the modelling of the revenue and price impacts of company tax.
- Whereas IE CGE allows for the revenue loss from profit shifting, CGETAX also allows for the economic waste from the associated tax avoidance activities.

When all of the effects taken into account are weighed up in a model simulation of changing the company tax rate, the negative disincentive effects dominate, leading to a high marginal excess burden (MEB) for company tax, as shown in section 4.

CGETAX models taxes on property as part of its modelling of the production of structure services that is depicted in Diagram 3.5. This includes stamp duty on conveyancing, municipal rates and land taxes.

Conveyancing duty is triggered on a change of property ownership. Thus, stamp duty is represented as a tax on investment in ownership transfer costs. This gives conveyancing duty a narrow base and a high implied tax rate. The role of ownership transfer costs in the production of structure services is shown in Diagram 3.5. Conveyancing duty means that the stocks of residential and commercial buildings are not used efficiently because of the tax disincentive against a change of ownership when circumstances change. This distortion is modelled separately for dwelling services and commercial building services.

As the Henry Review pointed out, land can be an efficient tax base because it is in fixed supply. Land's role in the production of structure services in CGETAX is shown in Diagram 3.5. CGETAX distinguishes between the supplies of residential land and non-residential land, and models the application to both of municipal rates and land taxes. Municipal rates are more broadly based than land taxes e.g. they apply to owner-occupied housing and agricultural land. However, even municipal rates are not always uniform across land uses and so they do distort land allocation. CGETAX captures this distortion by taking into account variations in municipal rates and land taxes across its 278 industries. The Henry Review recommended a reformed land tax that was uniform across land uses.

Diagram 3.5 Structure services in each industry

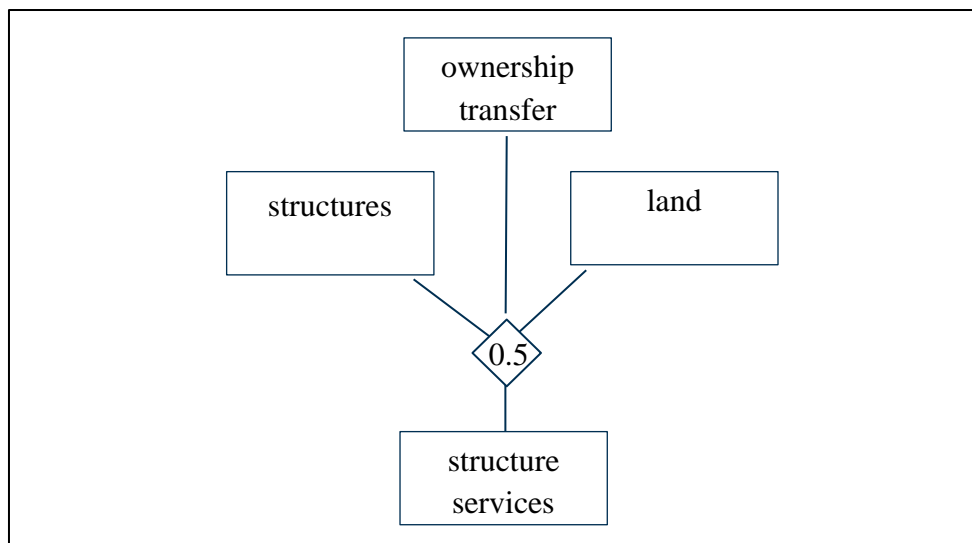
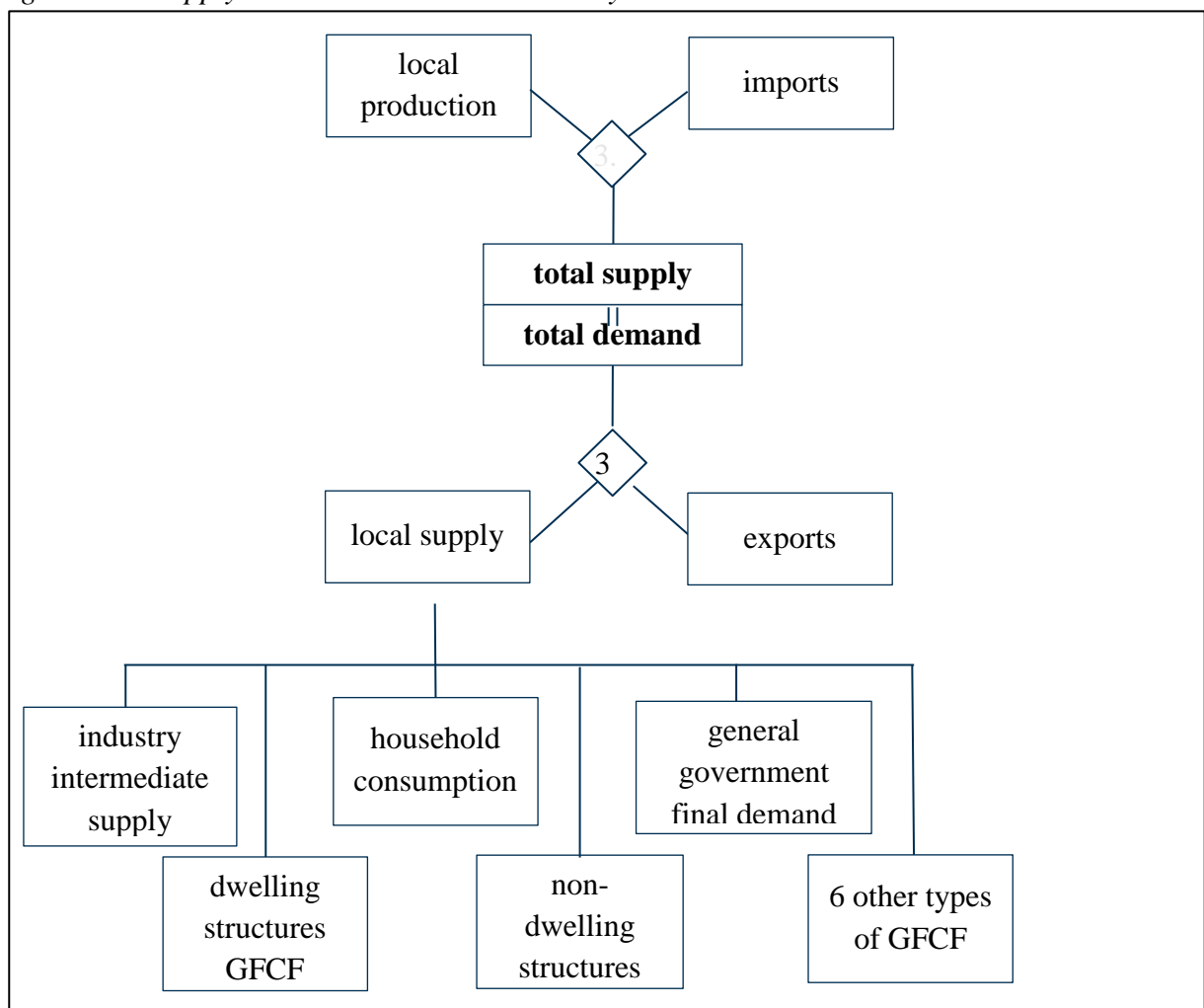


Diagram 3.6: Supply and Demand in each Industry



Elasticities

Both the theoretical analysis of section 2 and the appendix and the preceding discussion of the behavioural responses of households and businesses to taxes in CGETAX identified key elasticities that determine the strength of different responses. The choice of values for these elasticities is now discussed. The household elasticities, which determine the strength of the work and saving disincentive effects, are discussed first, followed by the industry elasticities, which determine the strength of the investment incentive and other disincentive effects.

The strength of the work disincentive effect from the labour market tax wedge depends on the compensated elasticity of the labour supply with respect to the post-tax wage. This in turn depends on two underlying parameters – the elasticity of substitution between leisure and consumption and the calibrated ratio of leisure time to work time. However, Ballard (2000) argues convincingly that it makes more sense to begin with values for elasticities of the labour supply with respect to the wage and work backwards to derive values for the two underlying parameters. This is for two reasons: labour supply elasticities are more readily observable and they drive estimates of the inefficiency of labour taxes.

In CGETAX, the elasticity of the labour supply with respect to the post-tax wage is set at 0.4 as a compensated elasticity and 0.15 as an uncompensated elasticity. Working backwards, this leads to an elasticity of substitution between leisure and consumption of 1.1 and a calibrated ratio of leisure to work time of 0.48.

The compensated elasticity is based on the widely-cited study of Gruber and Sayers (2002) who find an “elasticity of taxable income” of 0.4. This refers to the elasticity of declared labour income with respect to the marginal retention rate (defined as one minus the marginal tax rate). This is a broader concept than the labour supply elasticity, but is more appropriate for tax efficiency analysis. It captures the effects of labour income tax not only on labour supply, but also on avoidance and evasion. In addition, in a long run analysis, the disincentive effect of taxing labour income on investment in education and training should also be taken into account.

While the compensated elasticity determines the efficiency costs of labour income tax, the uncompensated elasticity is a more widely understood concept. The value used here of 0.15 is consistent with the literature. For example, Evers, de Mooij and van Vuuren (2008) find in favour of a lower value for men but a higher value for women.

The strength of the saving incentive effect depends on the elasticity of intertemporal substitution (EIS). Gunning, Diamond and Zodrow (2008) point out that the EIS values used in CGE models typically range from 0.25 to 0.50. Australia’s system of compulsory superannuation is likely to make voluntary saving less important, and so CGETAX uses the value for the EIS at the bottom of this range i.e. the EIS is set to 0.25.

The investment disincentive effect is driven by the elasticity of substitution between labour and capital. For this elasticity, the Gunning et al. (2008) literature survey reports values ranging from 0.4 to the Cobb-Douglas case of 1.0. Similarly, de Mooij and Devereux (2008) assume an elasticity of substitution of 0.7 in the CORTAX model of the EU countries.

Consistent with these studies, CGETAX uses values ranging from 0.7 to 0.9, depending on the type of capital. This can be seen from Diagram 3.1. The elasticity of substitution between labour and equipment is set to 0.9. For structures capital, the substitution with labour is indirect. The elasticity of substitution between structure services, which include structures, and the labour-equipment composite is 0.7.

The strength of the profit shifting effect depends on the semi-elasticity of the company tax base with respect to the company tax rate. This was originally set to -0.5 in the IE CGE model, based on a profit shifting effect in de Mooij and Devereux (2009). However, de Mooij and Devereux (2009) actually allowed for two separate profit shifting effects, and when these two effects are combined the total semi-elasticity is -0.73, which is the value adopted for CGETAX. There was further discussion of this choice of semi-elasticity in section 3.

The disincentive effect from stamp duty on conveyances depends on the elasticity of substitution in the production of structure services, as shown in Diagram 3.5. In particular, taxation of ownership transfer costs leads to substitution towards structures and land governed by an elasticity of substitution of 0.5. This value is based on Zhao (2010).

Marginal Excess Burdens

The MEB measures the consumer loss per dollar of improvement in the government budget from a small tax rise. Importantly, the gain to the government budget is returned to the consumer as a lump-sum transfer (“transfer”), so the consumer loss that is measured only reflects the disincentive or substitution effects from the tax rise.

In CGETAX, this consumer loss is measured by the equivalent variation (EV), the maximum amount consumers would be prepared to pay to stop the tax rise occurring. To construct the EV, the first step is to derive the indirect utility function that corresponds to the direct utility function.

The CGETAX direct utility function, U , was presented earlier and is reproduced below for ease-of-reference.

$$U = \left\{ \int_0^{\infty} e^{-\rho \cdot t} u(t)^{\varepsilon} \cdot p(t) dt \right\}^{1/\rho}$$

The corresponding indirect utility function, V , takes the following form, which has three terms.

$$V = \left\{ \frac{MF\$}{pu((1 - tnm).w, pc)} \right\} \cdot \left\{ \frac{rm - grc}{rm - gr} \right\} \cdot \left\{ [(1 - tam).rm - grc]^{\frac{\sigma t}{1 - \sigma t}} \right\}$$

The first term is real income in a static setting. In the numerator is nominal full income, $MF\$$, which is defined as full labour income (inclusive of the value of leisure time), plus asset income, plus transfers, net of labour and asset income taxes. Nominal full income is available to spend on consumption and leisure. The denominator deflates this using the ideal price index, pu , for the consumption-leisure composite, which depends on the after-tax wage and the price of consumption.

The second term reflects the intertemporal budget constraint. It equals one in the baseline scenario, where the rate of growth in per capita consumption is calibrated to equal the rate of productivity growth, γ .

The third term captures the loss of utility from taxation of asset income. An increase in the marginal rate of tax on asset income, tam , reduces this term, and the sensitivity of utility to this depends on the EIS, σt .

Given this indirect utility function, the EV is defined as shown below. Here the second and third terms in the expression above for indirect utility are represented by T2 and T3. Superscripts of “b” and “a” are used to represent values before and after a tax change.

$$\left\{ \frac{MF\$^b - EV}{pu^b} \right\} \cdot T2^b \cdot T3^b = \left\{ \frac{MF\$^a}{pu^a} \right\} \cdot T2^a \cdot T3^a$$

Solving this gives the following equation for EV.

$$EV = MF\$^b - \frac{pu^b}{pu^a} \cdot \frac{T2^a}{T2^b} \cdot \frac{T3^a}{T3^b} \cdot MF\a$

The MEB is then calculating by dividing the EV by the budget-balancing lump-sum transfer.

$$MEB = EV/\text{transfer}$$

4 Marginal Excess Burdens (MEBs)

This section presents estimates of the economic efficiency cost or marginal excess burden (MEB) of each tax. As discussed previously, the MEB measures the consumer loss per dollar of improvement in the government budget from a small tax rise, over and above the amount of revenue that is raised. The consumer loss reflects the economic disincentive effects from the tax rise.

The MEB estimate for a tax is obtained by simulating a small rise in that tax in CGETAX. The MEB is then obtained using the procedure outlined in section 3. The values for the MEBs reflect the theoretical analysis provided in section 2 and the appendix as well as the CGETAX extensions and choice of parameter values described in section 3.

The MEBs of the major taxes – personal income tax, GST and company tax – are discussed first. This is followed by a discussion of the MEBs of other taxes. All of these MEBs are presented in the “CGETAX” column of Table 4.1.

Table 4.1 Marginal Excess Burdens of Taxes (per cent of net revenue)

Tax Change	GCETAX
Company income tax:	
CIT from 25% to 30%	139%
Personal and super income taxes:	
PIT surcharge	41%
PIT income levy	31%
PIT bracket creep	18%
labour income levy	33%
asset income levy	18%
reduce franking credits	16%
GST:	
raise rate	18%
broaden base to fresh food	10%
Payroll Tax:	
raise rate	37%
reduce threshold	24%
Property taxes:	
municipal rates	23%
land tax	48%
conveyancing duty: residential	87%
conveyancing duty: commercial	195%
Insurance taxes	58%

Source CGETAX simulations

Personal and Superannuation Income Tax

Within CGETAX, personal income tax and superannuation income tax are both mapped to taxes on labour income and asset income. Labour income tax includes personal income tax, as it applies to labour income, plus tax on superannuation contributions. Asset income tax includes personal income tax, as it applies to asset incomes, plus tax on superannuation earnings.

CGETAX takes into account the concessional tax rates applied to superannuation contributions and earnings. It also takes into account the progressive nature of the personal income tax scale by distinguishing between representative average and marginal rates of personal income tax. Finally, it allows for the franking credit system within both personal income tax and superannuation income tax. In all cases, implicit tax rates are used and these are calibrated to actual tax collections. For example, CGETAX takes into account that utilised franking credits typically only represent about 30 per cent of company tax collections.

The MEB from a rise in personal and/or superannuation income tax depends on the nature of the rise. It varies depending on whether the rise:

- targets labour incomes or asset incomes;
- is progressive or regressive; and
- applies to concessional or standard rates of tax.

CGETAX captures the first two issues. It separately models the disincentive effects from taxing labour and asset incomes. It also distinguishes between marginal and average tax rates: the relative movements in these can be used to assess the progressivity of a tax change.

CGETAX does not fully capture the third issue. In combining personal income tax and superannuation tax rates in constructing overall tax rates for labour income and asset income, it uses fixed weights. It therefore does not capture the shifting out of concessional tax assets that can be expected if tax concessions are reduced. Hence, the analysis here focusses on the first two issues.

The benchmark MEB for personal income tax is 31 cents per dollar of revenue, as seen in Table 4.1. This is estimated by imposing a small levy calculated as a fixed percentage of income. This MEB reflects both the labour supply disincentive effect from taxing labour income and the saving disincentive effect from taxing asset income.

These two disincentive effects can be isolated by considering the effects of two separate levies, one applying to labour incomes and one applying to asset incomes. As seen in Table 4.1, a labour income levy has an MEB of 33 cents per dollar of revenue, while an asset income levy has an MEB of 18 cents per dollar of revenue. The overall MEB for personal

income tax of 31 cents per dollar of revenue can be interpreted as a weighted average of the two separate MEBs for labour income tax and asset income tax.

The MEB for labour income tax is now considered in more detail. This is followed by an analysis of the MEB for asset income tax.

Labour income tax

As seen in Table 4.1, the levy on labour income has an MEB of 33 cents in the dollar, reflecting the labour supply disincentive effect. As an economic cross-check on this result, it is useful to estimate this MEB in an alternative way, drawing on the theoretical analysis of section 2 and the appendix. There it was shown that the MEB for a tax on labour income is given by the following formula.

$$\frac{\eta \cdot tlab}{1 - \eta \cdot tlab} \quad [1]$$

Here, η represents the compensated elasticity of the labour supply with respect to the real, marginal post-tax wage. As discussed in section 3, this elasticity is set to 0.4 in CGETAX.

The other determinant of the MEB for labour tax in the formula is the comprehensive tax rate on labour, $tlab$. From section 2 and the appendix, this encompasses taxation of labour income both directly through personal income tax as it applies to labour income and superannuation contributions tax, and indirectly through payroll tax, company income tax and, to the extent that household consumption is funded out of labour income, GST.

Before using this formula from the Stylised model, it is refined in two ways. First, the tax rate in the original formula expresses tax payments as a percentage of post-tax labour income, whereas in CGETAX labour tax rates express tax payments as a percentage of pre-tax labour incomes, in line with convention. Second, the Stylised model assumes labour income tax is proportional, whereas in reality personal income tax is progressive. CGETAX takes this into account by distinguishing between average and marginal tax rates on labour income. After making these two refinements, the derived formula for the MEB for labour income taxes is as follows.

$$\frac{\eta \cdot \frac{tlab'_m}{1 - tlab'_m} \cdot \frac{dtlab'_m}{dtlab'_a}}{1 - \eta \cdot \frac{tlab'_a}{1 - tlab'_m} \cdot \frac{dtlab'_m}{dtlab'_a}} \quad [1a]$$

In this formula, prime superscripts are used to indicate that tax rates are now expressed as a percentage of pre-tax income incomes. Subscripts are used to distinguish between average (a) and marginal (m) tax rates.

To apply this formula, total average and marginal tax rates on labour are calculated in Table 4.2 as 35.6 and 40.4 per cent respectively. The difference between these two rates emanates

from the progressive nature of the personal income tax (PIT) scale, as seen in the “PIT on labour income” row of the table.

The raw PIT average and marginal tax rates were 21.4 and 31.0 respectively. However, as discussed in section 3, it is assumed that labour supply decisions occur at both the extensive margin, where average tax rates drive decisions, and at the intensive margin, where marginal tax rates drive decisions, with a 50/50 weighting. Applying this weighting, the PIT tax rate driving labour supply decisions in the model is 26.1 per cent, as shown in Table 4.2.

Table 4.2 Total Average and Marginal Tax Rates on Labour in CGETAX

	average	marginal
PIT on labour income	21.4%	26.1%
super contributions	0.8%	0.8%
Payroll tax	2.5%	2.5%
Company Income Tax	6.7%	6.7%
GST from labour-funded consumption	4.3%	4.3%
total labour tax	35.6%	40.4%

Source: CGETAX baseline scenario

The other factor determining the labour tax MEB in the formula is the nature of the tax rise. For a distributionally neutral tax rise such as the fixed percentage levy on labour income, the simple change in average and marginal tax rates is the same. In that case the adjustment factor in the formula of

$$\frac{dtlab'_m}{dtlab'_a}$$

equals one.

The formula can now be used to provide the economic cross-check on the labour tax MEB. Inserting the total average and marginal tax rates of 35.6 and 40.4 respectively, the compensated labour supply elasticity of 0.4, and the adjustment factor of one gives an MEB of 36 per cent. This is close to the CGETAX estimate reported in Table 4.1 of 33 per cent. This provides solid confirmation that the MEB estimate from CGETAX of 33 per cent is consistent with the first principles economic analysis set out in section 2 and the appendix.

The slight difference between the CGETAX and formula-based estimates of the labour tax MEB would be due to a wide range of factors that are taken into account in CGETAX but not in the Stylised model used to derive the formula in section 2 and the appendix. For example, the presence of fixed factors of production in CGETAX (land and mineral resources) reduces economic flexibility and hence tends to reduce estimates of MEBs. Also, economic contractions in CGETAX tend to lead to a small rise in the terms-of-trade, which will also reduce estimates of MEBs.

Progressivity and Regressivity

The foregoing discussion refers to a distributionally-neutral rise in labour tax rates. Now we consider rises that are more progressive or regressive. This time the MEB formula is used first followed by the CGETAX model.

A more progressive tax rise by definition will raise marginal tax rates by more than average tax rates, leading to a higher MEB. For example, a tax surcharge, calculated as a fixed percentage of tax payable, will lead to the same percentage increase in marginal and average tax rates, rather than the same simple increase. This lifts the adjustment factor in the formula from 1.0 to 1.222, which in turn raises the formula-based labour tax MEB from 36 per cent to 47 per cent, a lift of 11 percentage points.

Conversely, a regressive tax rise by definition will raise marginal tax rates by less than average tax rates, leading to a lower MEB. Bracket creep is an example of a regressive tax rise. In the absence of adjustments in tax brackets, wage inflation eventually results in lower wage earners being taxed at rates originally designed for higher wage earners, neutralising the original redistributive intent. In a simulation of a typical year of bracket creep using the Independent Income Tax Model (ITM), the representative average tax rate rises by 0.36 percentage points while the representative marginal tax rate rises by only 0.12 percentage points. Using this shift in average and marginal tax rates in the MEB formula (after applying the 50/50 weighting referred to above) reduces the MEB from 36 per cent to 22 per cent.

Thus, depending on the nature of the tax rise, the labour tax MEB formula estimates an MEB of 22 to 36 to 47 per cent, a range of 25 percentage points.

Turning to CGETAX, similar tax rises were considered, but this time for personal income tax rather than a hypothetical labour income tax. For the CGETAX simulations, depending on the nature of the tax rise, the MEB varied from 18 to 31 to 41 per cent, a range of 23 percentage points, as seen in Table 4.1. This is similar to the range of 25 percentage points generated by the formula.

This provides further confirmation that the MEB estimates from CGETAX are consistent with the conventional economic analysis set out in section 2 and the appendix. Thus, the formula provides a good guide to the sensitivity of the labour tax MEB in CGETAX to the three factors that drive it: the compensated elasticity of the labour supply with respect to the marginal post-tax real wage, the size of the existing labour market tax wedge when all taxes falling on labour are considered, and the progressivity or regressivity of the tax increase being considered.

Personal income tax is progressive by design, with the aim of improving equity. Ideally, the degree of progressivity in the personal income tax scale would be set by balancing the equity benefit from more progressivity against the efficiency cost.

Asset Income Tax

Taxing asset income has a saving disincentive effect. Saving and borrowing improve consumer welfare by allowing households to time their consumption expenditure to match their relatively stable consumption needs, rather than to be locked to the life cycle fluctuations of their incomes. Personal income tax and superannuation earnings tax discourage this consumption-smoothing process by reducing the after-tax rate of return from saving.

In CGETAX the MEB from a levy on asset income is simulated to be 18 cents per dollar of additional revenue, as seen in Table 4.1. Again, this result can be interpreted using the corresponding MEB formula derived in section 2 and the appendix.

$$\frac{\sigma t.ta \cdot \frac{rm}{(1-ta) \cdot rm - gr}}{\frac{(rm - gr) \cdot kd}{M} - \sigma t.ta \cdot \frac{rm}{rm - gr}} \quad [6]$$

In one sense, this takes a similar form to the other MEBs. For example, consider the simplest form for the MEB for labour tax that was given earlier and is reproduced below.

$$\frac{\eta \cdot tlab}{1 - \eta \cdot tlab}$$

For labour tax, the MEB reflects a labour supply disincentive effect driven by the product of the compensated labour supply elasticity (η) and the labour tax rate ($tlab$). Analogously, for asset income tax, the MEB reflects a saving disincentive effect driven by the product of the elasticity of intertemporal substitution (σt) and the asset income tax rate (ta). However, the MEB formula for asset income tax differs in an important way from the other MEB formulas.

For labour income tax, there is a symmetry between the disincentive effect and the tax base: both depend on employment. Hence, the denominator of the MEB expression is based on unity.

In contrast, for asset income tax the disincentive effect relates to full consumption expenditure and its timing, whereas the tax base of asset income is much narrower. Asset income funds only 12 per cent of full consumption (consumption plus leisure) in the baseline scenario of CGETAX. This low share appears in the denominator of the MEB expression for asset income tax, pushing up the MEB.

$$\frac{(rm - gr) \cdot kd}{M}$$

So other things being equal, asset income tax has a poor revenue yield relative to its disincentive effects. This point can be appreciated by considering the comparative impact of asset income tax on two individuals, both with the same total income. The individuals differ

in the source of their income, one receiving asset income from an inheritance and the other earning labour income.

An increase in asset income tax leads to the same distortion for both individuals, with present consumption being substituted for future consumption. Hence the welfare cost is also the same. However, the government budget gain from higher asset income tax is much larger from the individual with the inheritance than from the individual relying on labour income. So the asset income tax has a lower MEB for the first type of individual but a higher MEB for the second type of individual. Because in aggregate labour income is the dominant source of income, the case of the second individual is more important and so there is the potential for asset income tax to have a high MEB. That is, the revenue yield from a tax rise may be small relative to the induced shift from future to present full consumption.

Notwithstanding the narrow tax base of asset income tax, its MEB of 18 cents per additional dollar of revenue is relatively low. This reflects the two other factors driving this MEB.

The first of these factors, the tax rate on asset income, is low. In the baseline scenario of CGETAX, the average tax rate on asset income is only 5 per cent compared to over 35 per cent for labour income (see Table 4.2). Asset income tax is low because imputed income from owner-occupied housing is tax free, superannuation earnings are taxed at low rates of 0, 10 and 15 per cent, and franking credits represent a saving subsidy or negative asset income tax.

The second of these factors is the elasticity of intertemporal substitution (EIS). It is set to a low value of 0.25 in CGETAX. This choice is discussed in section 3.

To conclude, the narrow base of asset income tax makes it a potentially inefficient, warranting a substantially lower tax rate than for labour income. However, asset income is already taxed at a low rate, and mainly because of this its MEB is moderate.

GST

As a tax on consumption expenditure, GST has no such saving disincentive effect. It taxes consumption expenditure at the same rate, irrespective of its timing.

At the same time, like labour income tax, GST does have a labour supply disincentive effect. Both taxes reduce the additional amount of consumption that can be funded from an additional hour of work.

One important difference is that GST is a proportional tax so there is no distinction between marginal and average rates of GST. In contrast, labour income tax is progressive so, depending on the design of a tax rise, it may increase marginal tax rates by more or less than average tax rates. The way in which progressivity increases MEBs was considered above.

To make a more direct comparison, GST can be compared with a labour income levy. Both are proportional taxes and both have a labour supply disincentive effect. However, Table 4.1 shows that the GST is more efficient with an MEB of only 18 per cent compared to 33 per cent for the labour income levy.

The main reason for this difference was highlighted in the theoretical analysis of section 2 and the appendix. The tax base for GST, household consumption, is funded out of both labour income and non-labour income. GST only acts as a labour supply disincentive to the extent that it is funded out of labour income. To the extent that it is funded out of asset income and government transfers, it has no disincentive effect in CGETAX. Applying the formula derived in section 2 and the appendix, Table 4.3 shows that only 71 per cent of revenue raised through GST has a labour supply disincentive effects. This accounts for most of the gap between the labour income levy MEB and the GST MEB.

Table 4.3 Funding of Household Consumption

after-tax labour income	71%
unsaved after-tax asset income	15%
government transfers	14%
consumption	100%

Source: CGETAX baseline scenario

As noted in the appendix, this analysis of the GST MEB should be qualified by the fact that some government transfers are related to labour income. An analysis of the efficiency impacts of government transfers is outside of the scope of this study.

The fact that consumption is partly funded from non-labour income also has equity implications compared to labour income tax. On the one hand, by taxing transfer payments, which are skewed towards the less well off, GST is likely to be less equitable than labour income tax. On the other hand, by taxing unsaved asset income, which is skewed towards the more well off, GST is likely to be more equitable than labour income tax.

The other key difference from an equity perspective is the point made earlier that labour income tax is applied on a progressive rate schedule. This makes it both less efficient and more equitable than if it were applied as a fixed proportion of income.

The fact that GST revenue partly originates from non-labour income is the main reason that GST is more efficient than a labour income levy. It explains 10 out of the 15 percentage points difference between the MEBs of 18 and 33 per cent. The remaining difference is attributable to the application of GST to spending by foreign tourists on Australian services. Because demand for these services is not perfectly price elastic, this export tax provides a small terms-of-trade benefit.

Finally, it is more efficient to broaden the base of GST to include fresh food, with an MEB of 10 cents per dollar, than to raise the rate incrementally, with an MEB of 18 cents per dollar

(Table 4.1). This is consistent with the general principle that broader-based taxes are more efficient. In this case, broadening the GST base to include fresh food would overcome the current GST disincentive against consumption of served and processed food.

Company Income Tax

As discussed previously, in modelling domestic investment, CGETAX (like the Stylised model) makes the common assumption that Australia is a small open economy. With foreign investors having a wide choice of countries to invest in, company tax becomes a cost that adds to the hurdle rate of return for investing in a country. A higher Australian company tax rate will therefore reduce investment in Australia, leading to a lower capital-to-labour ratio. This is the investment disincentive effect from higher company tax.

Because company tax adds to their hurdle rate of return for investing in a country such as Australia, in the long run it does not squeeze post-tax returns to foreign investors. Instead it squeezes local real wages. This is true to the extent that company tax applies to normal returns to capital rather than economic rents. This squeeze in local real wages means that company tax also has a labour supply disincentive effect.

Thus, company tax not only has a labour supply disincentive effect like the labour-based taxed, but in addition it has an investment disincentive effect that reduces the capital-labour ratio and productivity. This leads to the widespread finding that company tax is a highly inefficient tax.

These two effects are captured in the MEB formula for company tax, as it applies to normal returns to capital. Taking the MEB formula derived for the Stylised model of section 2 and the appendix and generalising it to distinguish between marginal and average rates of labour tax gives the following.

$$\frac{\eta \cdot \frac{tlab'_m}{1-tlab'_m} + \frac{\sigma}{\alpha} \cdot tke}{1 - \eta \cdot \frac{tlab'_a}{1-tlab'_m} - \frac{\sigma}{\alpha} \cdot tke} \quad [3a]$$

Taking into account only the labour supply disincentive effect (via η), the MEB is 36 cents per additional dollar of revenue, the same as for the labour income levy. After also allowing for the investment disincentive effect (via σ), the MEB rises to 80 cents per additional dollar of revenue. In Australia compared to other countries, there are two further factors adding to the inefficiency of company tax.

First, Australia has a relatively high corporate tax rate. Devereux et al. (2016) from the Oxford University Centre for Business Tax project that by 2020, after taking into account announced future changes in corporate tax, Australia will rank 15th among the G20 countries for having an internationally competitive effective average tax rate (EATR). The EATR “is generally the relevant measure for comparing the incentive to locate new economic activity in

different countries”. This uncompetitive EATR for corporate tax is despite Australia’s high reliance on foreign investment. From 2015 to 2020 alone, Australia is projected to slide from 11th to 15th position in the G20 rankings because of cuts to corporate tax in other countries (Devereux et al., 2016).

This high existing Australian company tax rate means that there are greater costs from company tax increases and conversely greater benefits from tax cuts, compared to countries with lower company tax rates. This is discussed further in section 5.

Table 4.4 Projected G20 Statutory and Effective Average Tax Rates in 2020

Position	Country	Statutory tax rate	Country	Effective Average tax rate
1	Norther Ireland	12.50%	Northern Ireland	11.99%
2	Great Britain	17.00%	Great Britain	15.82%
3	Indonesia	18.00%	Indonesia	16.56%
4	Russia	20.00%	Russia	16.71%
5	Saudi Arabia	20.00%	Turkey	16.91%
6	Turkey	20.00%	Korea	18.00%
7	Korea	22.00%	Saudi Arabia	18.08%
8	China	25.00%	Italy	21.35%
9	Italy	26.54%	China	21.43%
10	Canada	26.75%	Canada	23.27%
11	South Africa	28.00%	France	23.70%
12	India	28.84%	South Africa	24.13%
13	France	28.92%	India	25.63%
14	Australia	30.00%	Mexico	26.11%
15	Mexico	30.00%	Australia	26.63%
16	Germany	30.95%	Germany	27.04%
17	Japan	33.06%	Japan	29.21%
18	Brazil	34.00%	Brazil	30.68%
19	Argentina	35.00%	Argentina	32.26%
20	USA	40.46%	USA	34.85%

Source: Devereux et al. (2016)

The other factor adding to the inefficiency of Australian company tax is our franking credits system. By refunding around 30 per cent of company tax collections, it erodes the net revenue yield from company tax. This is also discussed further in section 5.

A high company tax rate also leads to greater profit shifting to lower rate jurisdictions. The associated waste of resources on tax avoidance activity adds to the consumer welfare cost of company tax, and the profit shifting also reduces the revenue yield. Both of these effects add to the MEB for company tax. For further analysis of company tax and profit shifting in the Australian context, see Murphy (2016a) for a general discussion and Murphy (2016b) for an analytical treatment.

To summarise, in open economies company tax is inherently an inefficient way of raising revenue because of its disincentive effects on labour supply and the capital-to-labour ratio. In Australia's case the inefficiency is even greater because of our internationally uncompetitive rate and our franking credit system.

CGETAX captures all four of these factors adding to the MEB for company tax. It also allows for mitigating effects, two of which are the more significant. These are that company tax falls partly on economic rents and that a limited group of foreign investors receive tax credits in their home country for company tax paid abroad. These two effects are now discussed in turn.

CGETAX recognises that part of company tax is collected from economic rents rather than from normal returns to producible capital. As discussed in more detail in section 3, these rents include both oligopoly rents in certain sectors and so-called Ricardian rents on business land and minerals. Table 4.5 shows normal gross returns to capital represent 24 per cent of gross value added, compared to 4 per cent for Ricardian rents and 5 per cent for oligopoly rents.

As shown in section 2 and the appendix, to the extent that company tax falls on such rents, it has a negative MEB equal to the share of those rents that is foreign owned. This makes company tax less inefficient. However, this benefit could also be obtained from directly taxing such rents, thereby avoiding the many inefficiencies associated with company tax.

Table 4.5 Income Shares of Gross Value Added

Income Source	
labour	59%
housing capital	9%
producible business capital	24%
business land and mineral rents	4%
oligopoly rents	5%
	100%

Source: CGETAX baseline scenario

CGETAX also recognises that a very limited group of foreign investors receive tax credits in their home country for company tax paid abroad. For such foreign investors, this negates the potential incentive effect from a company tax cut in Australia or other host countries. The US gives tax credits for this offshore company tax, but only for direct investment, not portfolio investment, and only to the extent that profits are remitted to the USA rather than retained in the host country. These tax credits represent an average of 5 per cent of Australian company tax collections and this is modelled in CGETAX. Most countries other than the US now operate "source" based systems under which company tax is only applied to profits sourced locally so that foreign investments are not taken into account. Investors from such countries pay their Australian company tax in full, without any relief from tax credits in their home country.

CGETAX also takes into account many other features of the Australian company tax system. These include immediate write-off provisions for mineral exploration, R&D tax offsets, debt deductibility and depreciation allowances based on historic cost rather than replacement value.

Taking all modelled effects into account, including the six effects discussed in detail above, CGETAX simulates an MEB for company tax of 139 cents per dollar of additional revenue. As shown in Table 4.1, this refers to the impact of maintaining the company tax rate at 30 per cent rather than reducing it to 25 per cent. This compares to the MEBs for the other major taxes – personal income tax and GST – of under 50 cents. This makes reducing the company tax rate to 25 per cent the top priority for tax reform in Australia.

The MEBs of the other taxes are now discussed. Most of these other taxes are more narrowly-based than the major taxes. In general, a tax will have a relatively low MEB if it is applied at a low rate to an immobile base. Such a tax is likely to have only a modest impact on economic choices. Conversely, a tax will have a relatively high MEB if it is applied at a high rate to a mobile base. It is likely to heavily distort economic choices relative to a situation in which the tax was not applied. These ideas can be applied in interpreting the remaining MEBs presented in Table 4.1.

Payroll Tax

Payroll tax is another form of labour tax, comparable in some ways to personal income tax as it applies to labour income. One difference is that the legal incidence of payroll tax falls on employers while the legal incidence of personal income tax falls on the other side of the labour market i.e. on workers. However, a basic principle of tax policy analysis is that the economic incidence does not vary with the side of the market on which a tax is applied. The theoretical analysis of section 2 and the appendix shows that in an open economy the long-run economic incidence of both of these labour taxes falls on labour.

As a tax applied as a proportion of labour income, payroll tax is most directly comparable with the labour income levy. However, Table 4.1 indicates that payroll tax has a higher MEB, of 37 cents per dollar of additional revenue compared to 33 cents for the labour income levy. This is primarily because of the small business exemption from payroll tax. This exemption distorts the pattern of employment away from larger firms and towards smaller forms, generating an inefficiency.

Similarly, the efficiency of payroll tax could be improved by reducing the small business threshold to broaden the base. This method of raising additional payroll tax revenue has an MEB of only 24 cents, as seen in Table 4.1.

Conveyancing Duty

For reasons explained in section 3, conveyancing duty is represented as a tax on investment in ownership transfer costs, giving it a narrow base and a high implied tax rate. This meets both of the conditions for an inefficient tax. Conveyancing duty means that the stocks of residential and commercial buildings are not used efficiently because of the tax disincentive against a change of ownership when circumstances change.

Conveyancing duty is modelled separately for dwelling services and commercial building services. The respective MEBs are 87 and 196 per cent (Table 4.1). Arguably these high MEBs mean these taxes should be abolished.

Municipal Rates and Land Tax

Shifting from land tax (MEB of 48 cents in the dollar) to the more broadly-based municipal rates (MEB of 23 cents in the dollar) would improve the efficiency of land taxation. A further efficiency gain would be available by removing discrimination in municipal rates between land uses, as recommended by the Henry Tax Review.

Insurance Taxes

Insurance taxes appear to be applied at moderate rates when expressed as percentages of premiums. However, the true price of an insurance service to a customer is the premium net of the expected benefit. When re-expressed in this way, insurance taxes are seen to be levied at high effective rates on narrow bases. Insurance is voluntary more often for households than for businesses, so most of the disincentive effects from insurance tax are likely to arise from it inducing some households not to take out some types of insurance cover.

Unlike other models that identify a single insurance and superannuation industry, CGETAX distinguishes four different insurance industries: life insurance, health insurance, motor vehicle insurance and other general insurance. Of these, motor vehicle insurance and other general insurance are the most heavily taxed, so this disaggregation of the insurance industry helps capture the high-tax, high-excess burden segment. In light of its high MEB, estimated here at 58 cents in the dollar (Table 4.1), arguably insurance taxes should be abolished.

Consumer Welfare vs GDP

MEBs are an appropriate way to gauge the efficiency of taxes because they reflect marginal long-term impacts on living standards, as measured by consumer welfare. While the literature of tax reform emphasises consumer welfare impacts, popular discussion sometimes refers to GDP impacts. Some of the shortcomings of GDP impacts compared to consumer welfare impacts are as follows. GDP impacts place no value on leisure time, no value on being able to save or borrow, no cost to negative externalities, they treat any gain in production the same irrespective of whether the additional income from that production is

received by Australians or foreigners, and they treat any gain in production as a benefit, irrespective of whether its value covers its investment funding costs.

Comparison with 2015 Treasury Working Paper

Table 4.6 compares the CGETAX estimates of the MEBs for the major taxes presented in this section with earlier estimates in a Treasury Working Paper (Cao et al, 2015).

Table 4.6 Comparison of MEBs

Organisation	Treasury	IE	IE	IE
Model	IE CGE	CGETAX	CGETAX	CGETAX
Variation		less profit shifting + no oligopoly	no oligopoly	
company income tax	50%	63%	120%	139%
labour income levy	21%	25%	25%	33%
personal income levy	16%	24%	24%	31%
GST	19%	14%	14%	18%

Sources: this paper, Cao et al. (2015)

As discussed in section 3, the Treasury modelling is based on Treasury's version of the IE CGE model and CGETAX also used the IE CGE model as its starting point. This common origin of the two models means that there are important structural similarities. At the same time, there has been more development work on CGETAX, leading to some differences between the MEBs in the two modelling exercises. To draw out the effect of some of these developments, Table 4.6 also shows the effects of removing some of the developments in CGETAX.

All four columns of model results in Table 4.6 show a high MEB for company tax. This is due in each case to the four factors discussed earlier – the disincentive effects on the labour supply and the capital to labour ratio, profit shifting and the franking credits system.

At the same time, Table 4.6 shows that the MEB for company tax is substantially higher for CGETAX at 139 cents per additional dollar of revenue than for the Treasury working paper at 50 cents. It also shows that much of this difference can be explained by the difference in profit shifting assumptions between the two models. As explained in section 3, CGETAX more fully reflects the strength of the profit shifting effects in de Mooij and Devereux (2009). This has little effect on the other MEBs.

Two other factors also contribute to the higher MEB for company tax in CGETAX. The same two factors also explain the higher MEB for a labour income levy, at 33 cents compared to 21 cents.

First, CGETAX takes into account the progressive nature of the personal income tax system, whereas the original IE CGE model assumed that it was a flat percentage rate tax. This

increases the estimate of the size of the labour market tax wedge: that wedge is based on marginal rates of tax and these are higher than average rates under a progressive tax system. Thus, in moving from IE CGE column to the first CGETAX column in the table, the MEB for the labour income levy rises from 21 to 25 cents per dollar of additional revenue.

Second, CGETAX takes oligopoly rents into account using mark-up pricing, whereas IE CGE simplified by attributing oligopoly rents to an unspecified fixed factor of production. Oligopoly rents allow more economic flexibility than a fixed factor, leading to larger estimates of gains from economic reform. Thus, in moving to the final column in Table 4.6, the MEB for the labour income levy rises from 25 to 33 cents.

Table 4.6 shows that this pattern of MEB results for a labour income levy largely carries over to a personal income levy, which applies to both labour and asset income. However, there is one significant difference. Both models include a labour supply disincentive from taxing labour income. However, CGETAX also introduces a saving disincentive effect from taxing asset income, leading to a smaller drop in the MEB when the levy is broadened from labour income to all of personal income, including asset income.

In CGETAX the MEB for GST (18 cents) is lower than the MEB for the labour income levy (33 cents), indicating that the GST is a more efficient tax. As explained in the GST section, GST has a weaker disincentive effect on the labour supply because 29 per cent of household consumption (the GST revenue base) is funded from non-labour incomes. In the Treasury working paper the MEB for GST (19 cents) is much closer to the MEB for labour income (21 cents).

5 Sensitivity of MEBs

The MEB estimates presented in section 4 were based on a particular set of assumptions. This section undertakes sensitivity analysis by investigating how the MEBs depend on allowances for imperfect competition, the assumed values of key parameters and the level of the existing tax burden. The sensitivity analysis draws on both the Stylised model and the full CGETAX model. The effects of imperfect competition on all of the MEBs are considered first, followed by an analysis for the major taxes of the sensitivity of their MEBs to parameter values and the tax burden.

Imperfect Competition

As noted in section 3, CGETAX recognises two types of economic rents in the business (non-housing) sector. First, it recognises economic rents due to the fixed factors of production of mineral resources and business land. Table 5.1, which reproduces Table 4.5, shows that these fixed factor rents are estimated at 4 per cent of total gross value added.

Table 5.1 Income Shares of Gross Value Added

Income Source	
labour	59%
housing capital	9%
producible business capital	24%
business land and mineral rents	4%
oligopoly rents	5%
	100%

Source: CGETAX baseline scenario

Even after allowing for these fixed factor economic rents, persistent above-normal rates of return on capital are apparent in several sectors, notably finance, telecommunications and beverages. For simplicity, the original IE CGE model assumed these remaining economic rents were due to unidentified fixed factors. However, the industry sectors in question are notable for their oligopoly structures. Hence, CGETAX makes the more realistic assumption that the rents in these sectors reflect imperfect competition. As evident from Table 5.1, this involved re-classifying economic rents that account for 5 per cent of GDP from fixed factor rents to oligopoly rents.

This reduced reliance on fixed factors in CGETAX compared to the original IE CGE model increases economic flexibility in the model. This leads to greater gains from economic reforms, including tax reforms. To isolate this effect, CGETAX was adjusted to revert to the previous treatment of economic rents. The resulting MEBs are shown in the “no oligopoly” column of Table 5.2. The effect of the switchover to oligopoly rents can be seen by comparing the “CGETAX” column with the “no oligopoly” column.

The switchover from unidentified fixed factor rents to oligopoly rents has the effect of raising estimates of labour-related MEBs by around 25 per cent. Previously changes in labour-related taxes were partly absorbed by these unidentified fixed factors, muffling behavioural responses. However, recognising the existence of imperfect competition in certain sectors improves the realism of the model. It also opens up the potential for using the model to assess the impacts of changes in competition policy in a more satisfactory way.

Table 5.2 Marginal Excess Burdens of Taxes (per cent of net revenue)

Tax Change	GCETAX	no oligopoly
Company income tax:		
CIT from 25% to 30%	139%	120%
Personal and super income taxes:		
PIT surcharge	41%	33%
PIT income levy	31%	24%
PIT bracket creep	18%	14%
labour income levy	33%	25%
asset income levy	18%	18%
reduce franking credits	16%	16%
GST:		
raise rate	18%	14%
broaden base to fresh food	10%	11%
Payroll Tax:		
raise rate	37%	29%
reduce threshold	24%	20%
Property taxes:		
municipal rates	23%	20%
land tax	48%	41%
conveyancing duty: residential	87%	75%
conveyancing duty: commercial	195%	165%
Insurance taxes	58%	57%

Source CGETAX simulations

The sensitivity of the MEBs for personal income tax as it applies to labour income, GST and company income tax are now considered in turn.

Labour Income Tax

From section 4, the MEB for personal income tax as it applies to labour income tax is given by the following formula.

$$\frac{\eta \cdot \frac{t_{lab}'_m}{1 - t_{lab}'_m} \cdot \frac{dt_{lab}'_m}{dt_{lab}'_a}}{1 - \eta \cdot \frac{t_{lab}'_a}{1 - t_{lab}'_m} \cdot \frac{dt_{lab}'_m}{dt_{lab}'_a}}$$

In this formula, the MEB depends in part on the nature of a tax change. For example, a tax surcharge maintains the progressivity of the income tax system. As explained in section 4, this involves setting

$$\frac{dt_{lab}'_m}{dt_{lab}'_a} = 1.222$$

The CGETAX MEB in this case is 44 cents per dollar of additional revenue, as shown in Table 5.3. Using the formula and the breakdown on labour tax revenues shown in Table 4.2, MEBs can be calculated under alternative assumptions. For example, varying the compensated labour supply elasticity from 0.3 to 0.4 to 0.5 varies the associated MEB from

30 to 44 to 61 cents. While these variations may appear substantial, it is notable that most MEBs are affected in a similar way. Thus, the implications for tax reform change little as the ranking of taxes from most to least inefficient remains largely unchanged.

This and other labour-related MEBs are also significantly affected by the size of the labour tax burden. As shown in Table 5.3, a halving in personal income tax as it applies to labour income would reduce the MEB from 44 to 25 cents per dollar of additional revenue. A lower labour market tax wedge means that there is a smaller gap between the value of an additional unit of labour in production and the value of an additional unit of leisure time, so tax changes are less distorting. Similarly, a 50 per cent increase in personal income tax as it applies to labour income would raise the MEB from 44 to 61 cents.

These two results taken together imply a mildly non-linear relationship between the tax burden and the MEB. This is because as the labour tax burden pushes higher, the vertical section of the Laffer Curve is approached, at which point the MEB tends to infinity. At that point there is a welfare cost from further tax increases but no revenue gain.

Table 5.3 Labour Income Tax Surcharge MEB Sensitivity (per cent of net revenue)

compensated labour supply elasticity:	
0.4 (base)	44%
0.3	30%
0.5	61%
rate:	
-50%	25%
current	44%
+50%	71%

Source CGETAX simulation for base; MEB formula for sensitivity

GST

Table 5.4 presents a similar analysis for the rate of GST, again using the relevant MEB formula. Again the expected positive relationship is seen between the compensated labour supply elasticity and the MEB. This time the MEB is less sensitivity to changes in the tax rate, varying in a narrow range from 17 to 18 to 19 cents. This is because the MEB depends on the total burden of labour taxes, and GST accounts for a relatively small share of that burden, as seen in Table 4.2.

Table 5.4 GST MEB Sensitivity (per cent of net revenue)

compensated labour supply elasticity:	
0.4 (base)	18%
0.3	13%
0.5	23%
rate:	
5%	17%
10%	18%
15%	19%

Source CGETAX simulation for base; MEB formula for sensitivity

Company Income Tax

Table 5.5 provides a sensitivity analysis for the MEB for company income tax. It considers certain economic assumptions, the level of the company tax burden and the influence of the franking credits system. The base case estimate of the MEB for company income tax is very high at 139 cents per additional dollar of tax revenue.

This very high MEB is partly attributable to refinements in economic assumptions in CGETAX compared to previous models in the series. In particular, CGETAX more fully reflects the strength of the profit shifting effects used in de Mooij and Devereux (2009). As explained in section 3, this involved increasing the semi-elasticity of the tax base with respect to the company tax rate from -0.5 to -0.73. CGETAX also more realistically accounts for oligopoly rents by using imperfect competition rather than an unidentified fixed factor, which further contributes to the very high company income tax MEB.

As foreshadowed in section 4, the very high MEB for company income tax is also due to company tax being more inefficient in Australia than in most other countries. This is for two reasons.

First, as detailed in Table 4.4, Australia's effective average rate of company tax is relatively high, making it more efficient. Table 5.5 shows that there is an MEB of 139 cents per additional dollar of revenue from maintaining the company tax rate at 30 rather than 25 per cent. This MEB drops to 96 cents from maintaining the company tax rate at 25 rather than 20 per cent; a 25 per cent company tax rate is more in line with the international norm. The MEB drops further to 68 cents from maintaining the company tax rate at 25 rather than 20 per cent.

This link from the level of the tax rate and the inefficiency of company tax occurs because a higher company tax rate adds to the tax wedge between the cost of capital to the economy and the return to capital. This means that there is a greater net benefit from stimulating additional investment by cutting company tax.

Second, by returning around 30 per cent of company tax collections to Australian shareholders, Australia's franking credits system erodes the overall gain to government revenue from company tax. It does this for only the minor saving efficiency benefit of reducing the effective tax rate on asset incomes.

Considering this in more detail, Table 5.5 shows that the Australian franking credits system raises the efficiency cost of company tax per dollar of revenue gain. It pushes the MEB up from 85 to 139 cents per additional dollar of revenue. Thus, the existence of the franking credits system in Australia further strengthens the case for cutting company tax. This reflects the effects of the franking credits system on both consumer welfare and the government budget when company income tax is cut.

Without a franking credits system, cutting the company tax rate from 30 to 25 cents would provide an annual welfare gain of \$5.8 billion. This only slips to \$5.2 billion under a franking credits system; the company tax cut reduces the value of franking credits, which has a mild saving disincentive effect.

Turning to the budget revenue impact, without a franking credits system, cutting the company tax rate from 30 to 25 cents would have an annual budget cost of \$6.9 billion. This cost shrinks substantially to \$3.7 billion under the franking credits system, because cutting the company tax rate reduces the cost of these tax credits to personal income tax and superannuation income tax collections.

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Appendix: Stylised Model in Detail

This appendix outlines a Stylised model of an open economy and uses it in a broad theoretical analysis of the efficiency of the major taxes. See section 2 for a general summary of this appendix.

The Stylised model covers personal income tax and superannuation income tax as they apply to labour income and asset income, corporate income tax, payroll tax and consumption tax. It captures the effects of these taxes on labour supply, the capital-labour ratio and the choice between present and future consumption. It does this while allowing for imperfect competition, with perfect competition as a special case.

CGETAX incorporates all of structure of the Stylised model, making the Stylised model a useful aid in understanding CGETAX. At the same time, as a large scale model, CGETAX is far more developed than the Stylised model. These other features of CGETAX are discussed in section 3.

This discussion of the Stylised model is divided into three sub-sections. First, the core of the Stylised model is presented, including taxes on labour, capital and consumption. Second, the marginal excess burdens of each of these taxes is analysed. Finally, the core model is extended to cover the taxation of asset income and its marginal excess burden.

Core of Stylised Model

The core of the Stylised model addresses taxation of labour, capital and consumption, while keeping domestic asset holdings fixed. The taxation of asset income and its effects on saving behaviour are considered later, in the extension to the Stylised model.

Producer and consumer behaviour are now considered in turn, before turning to the effects of taxes on consumer welfare and the government budget.

Producers

A representative firm produces output y using capital k and labour n under constant returns to scale.

$$y = f(k, n) \tag{1}$$

The oligopolist determines price by applying a mark-up factor m to marginal cost. This assumption for the form of oligopoly has the advantages that perfect competition can be allowed for as a special case ($m=1$), and the assumption of constant returns to scale can be maintained. It is the most common approach to oligopoly in CGE models (Roson, 2006).

Further, mark-up pricing is consistent with a number of theories of oligopoly. These include the well-known Cournot-Nash model, the conjectural variations model (Katz and Rosen, 1983 and Dung, 1993), which has the Cournot-Nash model as a special case, and the mark-up

strategy models of Grant and Quiggin (1994). These mark-up pricing models all have the common feature that they generate imperfect competition by assuming that the number of firms in an industry is fixed.

The mark-up factor can be constructed from the parameters of the underlying oligopoly theory that is selected. Alternatively, the mark-up factor may be estimated empirically from industry data on costs and profits and an assumed normal rate of return on capital, which is the approach taken in this paper.

Under a mark-up pricing oligopoly, the profit maximising marginal product conditions include the mark-up factor. The marginal product of labour equals the wage w after payroll tax has been applied at the rate tn , all marked up.

$$\frac{\partial f}{\partial n} = m. (1 + tn). w \quad [2]$$

Similarly, the marginal product of capital equals the marked up user cost of capital uc .

$$\frac{\partial f}{\partial k} = m. uc \quad [3]$$

In modelling the user cost of capital, the standard small open economy assumption is made. Specifically, the required, post-company tax rate of return is determined on world capital markets. Local company tax then becomes a cost that adds to the hurdle rate of return for domestic investment.

Under these assumptions, the cost of capital includes depreciation at the rate δ , the world required post-tax rate of return r and the added cost of company tax. The company tax rate tk' applies to the pre-tax rate of return, which is obtained by grossing up the required post-tax rate of return for company tax.

$$uc = \delta + r + tk' \frac{r}{1 - tk'} \quad [4]$$

For simplicity in the derivations, the company tax rate is alternatively defined as a proportion of the post-tax return, rather than the pre-tax return,

$$tk = \frac{tk'}{1 - tk'}$$

giving an alternative expression for the user cost of capital.

$$uc = \delta + r + tk. r \quad [5]$$

Combining equations [3] and [5], the marginal product of capital condition can be written as follows.

$$\frac{\partial f}{\partial k} = m.(\delta + r + tk.r) \quad [6]$$

Under constant returns to scale, Euler's Theorem can be used to show how output is absorbed by the incomes paid to labour, capital and oligopoly rents.

$$y = (1 + tn).w.n + uc.k + (m - 1).\frac{y}{m} \quad [7]$$

In the Stylised model, output is used for consumption c , investment i , government demand g , and net exports, nex .

$$y = c + i + g + nex \quad [8]$$

Government demand is taken to be exogenous. In the long run, investment needs to cover depreciation of the capital stock, plus growth in the capital stock at gr , the same rate as for output.

$$i = (\delta + gr).k \quad [9]$$

The post-company tax return on capital rm , includes the world required rate of return r , plus the contribution from oligopoly rents ro .

$$rm = r + ro \quad [10]$$

$$ro = (1 - tk').(m - 1).\frac{y/k}{m} \quad [11]$$

For external balance, net exports need to cover the return on foreign-owned capital kf less sustainable capital inflow.

$$nex = rm.kf - gr.kf \quad [12]$$

The capital stock is owned by foreign and domestic investors.

$$k = kf + kd \quad [13]$$

Consumers

Under the above assumptions, household consumption is determined residually in the GDP identity of equation [8]. In that identity, in the first instance substitutions are made for output (equation [7]), investment (equation [9]) and net exports (equation [12]). Further substitutions are then made for foreign-owned capital (equation [13]) and the user cost of capital (equation [5]), before simplifying to obtain the following consumption equation.

$$c = (1 + tn).w.n + tk.rm.k + (rm - gr).kd - g \quad [14]$$

This form of the consumption equation is convenient for analytical purposes. However, the more usual form is easier to interpret. It can be obtained by using the government budget constraint, which is as follows.

$$g + tr = tk.rm.k + tl.w.n + tn.w.n + tc.c + ta.rm.kd \quad [15]$$

The new fiscal items introduced in the government budget constraint are government lump sum transfers tr , the rate of tax on labour income tl , the rate of tax on asset income ta and the rate of tax on consumption tc . In modelling asset income tax revenue here, domestic asset holdings kd are held fixed, but this assumption is relaxed in the model extension covered later. Combining equations [14] and [15] gives the more easily interpreted form of the consumption equation.

$$(1 + tc).c = (1 - tl).w.n + tr + (1 - ta).rm.kd - gr.kd \quad [16]$$

This states that consumption inclusive of the value of consumption tax is equal to household income less saving. Household income includes after-tax labour income plus government transfers plus after-tax asset income. Saving is at a sustainable rate, so that locally-owned capital grows at the same rate as output. Again, this assumption is relaxed later in the model extension.

Having established the relationships for production and consumption, we now work with differentials to set up a comparative static analysis. In taking differentials, all exogenous variables are taken as fixed except for the tax rates. In differential form, the production function of equation [1] can be re-written as follows.

$$\frac{dy}{y} = \frac{dn}{n} + (1 - \alpha).(\frac{dk}{k} - \frac{dn}{n}) \quad [17]$$

Here α is the labour share of labour and capital income, defined as follows.

$$\alpha = \frac{(1+tn).w.n}{(1+tn).w.n + uc.k}$$

The two marginal product conditions of equations [2] and [3] lead to the condition for cost minimising changes in the capital-labour ratio, in which σ is the elasticity of factor substitution.

$$\frac{dk}{k} - \frac{dn}{n} = -\sigma.(\frac{duc}{uc} - \frac{d(1+tn)}{1+tn} - \frac{dw}{w}) \quad [18]$$

Taking differentials of equation [7] for output by income, and simplifying using the production function of equation [17] gives the factor price frontier.

$$0 = \alpha.(\frac{d(1+tn)}{1+tn} + \frac{dw}{w}) + (1 - \alpha).\frac{duc}{uc} \quad [19]$$

The real, post-tax wage facing workers, wc , is defined as follows.

$$wc = \frac{(1 - tl).w}{1 + tc}$$

Using this definition in the factor price frontier of equation [19] to eliminate the wage w , leads to the following solution for the worker real post-tax wage.

$$\frac{dwc}{wc} = - \left\{ \frac{d(1+tn)}{(1+tn)} + \frac{(1-\alpha)}{\alpha} \cdot \frac{duc}{uc} + \frac{d(1+tc)}{1+tc} - \frac{d(1-tl)}{1-tl} \right\} \quad [20]$$

With a given world, post-company tax required rate of return on capital, it can be seen that the worker real post-tax wage gains from a fall in payroll tax, consumption tax and labour income tax, as well as from a fall in the user cost of capital uc . Such a fall in the user cost of capital will occur if the rate of company tax is cut, as seen in the differential form of equation [5].

$$duc = r.dtkc \quad [21]$$

Turning to the modelling of labour supply, this begins with the concept of full consumption, which covers both consumption and leisure. A homothetic utility function is assumed in which full consumption is “produced” from consumption and leisure, $u(c, l)$. This leads to the following equation for changes in the optimal leisure-to-consumption ratio, where $\sigma(c, l)$ is the elasticity of substitution between leisure and consumption.

$$\frac{dl}{l} - \frac{dc}{c} = -\sigma(c, l) \cdot \left(\frac{d(1-tl)}{(1-tl)} + \frac{dw}{w} - \frac{d(1+tc)}{1+tc} \right) \quad [22]$$

Consumer Welfare

Taking differentials, the utility function can be re-written as follows.

$$\frac{du}{u} = \beta \cdot \frac{dl}{l} + (1 - \beta) \cdot \frac{dc}{c} \quad [23]$$

Here β is the leisure share of full consumption, defined as follows.

$$\beta = \frac{(1 - tl).w.l}{(1 - tl).w.l + (1 + tc).c}$$

With a fixed endowment of time T , changes in leisure time are exactly offset by changes in employment.

$$dn = -dl \quad [24]$$

where:

$$T = l + n$$

The Stylised model so far can be condensed down to a pair of equations involving changes in employment and consumption.

The first equation in this pair is obtained by differentiating the consumption equation [14], eliminating the changes in output, capital and wages using production-related equations [17]-[19], and simplifying.

$$dc = -dg + [(1 + tn).w.n + CIT].\frac{dn}{n} - \left[\frac{\sigma}{\alpha}.CIT - \sigma.\theta.\frac{ro}{1-tk'}.k \right].\frac{duc}{uc} + \frac{ro}{1+tk}.kf.dtk \quad [25]$$

Here CIT is company tax revenue and θ is the proportion of oligopoly rent that is retained nationally rather than leaked abroad.

$$CIT = tk.rm.k$$

$$\theta = tk' \cdot \frac{kf}{k} + \frac{kd}{k}$$

The second equation in the pair is obtained by starting with equation [22] for the change in the leisure to consumption ratio, eliminating wages using equation [19], eliminating leisure using equation [24] and using the relationship for the worker real post-tax wage given by equation [20].

$$\frac{dn}{n} = -\frac{l}{n} \cdot \frac{dc}{c} + \sigma(c, l) \cdot \frac{l}{n} \cdot \frac{dwc}{wc} \quad [26]$$

Equations [25] and [26] can be solved for consumption and employment. Equation [24] can then be used to solve for leisure. Finally, the solutions for consumption and leisure can be used in equation [23] to solve for consumer welfare.

$$\begin{aligned} dwelfare &= M \cdot \frac{du}{u} = -dg \\ &+ \eta \cdot \left[CIT + (tl + tn).w.n + \frac{tc}{1+tc} \cdot (1-tl).w.n \right] \cdot \frac{dwc}{wc} \\ &- \left[\frac{\sigma}{\alpha}.CIT - \sigma.\theta.\frac{ro}{1-tk'}.k \right] \cdot \frac{duc}{uc} \\ &+ \frac{ro}{1+tk}.kf.dtk \end{aligned} \quad [27]$$

Here M is full household consumption valued at its production cost, and η is the compensated elasticity of labour supply with respect to the worker real post-tax wage.

$$M = c + w^*.l = w^*.T - g + (rm - gr).kd \quad [28]$$

$$\eta = \sigma(c, l) \cdot (1 - \beta) \cdot \frac{l}{n}$$

where:

$$w^* = (1 + tn).w + CIT/n \quad [29]$$

In the above, w^* can be interpreted as the real wage facing producers, inclusive of company tax per worker.

Equation [27] shows how consumer welfare is affected directly or indirectly by increases in various tax rates. The indirect effects operate via wc and uc , which are linked to tax rates in equations [20] and [21] respectively. These effects on consumer welfare are a key determinant of the economic efficiency of each tax, as measured by its marginal excess burden.

The other ingredient needed for calculating marginal excess burdens is the effect of increases in each tax rate on the position of the government budget. This position is measured by the lump-sum transfer that could be returned to consumers from the benefit to the budget resulting from a tax rise. To determine this, the first step is to re-arrange the government budget identity of equation [15] to make government lump-sum transfers the subject.

$$tr = tk.rm.k + tl.w.n + tn.w.n + tc.c + ta.rm.kd - g \quad [30]$$

Totally differentiating and then solving gives the final result for the change in lump sum transfers.

$$\begin{aligned} dtr = & MC \cdot \frac{du}{u} \\ & -(1 - tl).w.n \cdot \frac{dwc}{wc} \\ & + \frac{tc}{1 + tc} [tr + [(1 - ta).rm - gr].kd] \cdot \frac{dtr}{tc} \\ & - \sigma.ro.kd \cdot \frac{duc}{uc} \\ & + \frac{ro}{1 + tk} .kd.dtk \end{aligned} \quad [31]$$

Here MC is full household consumption valued at consumer prices.

$$MC = (1 + tc).c + (1 - tl).w.l \quad [32]$$

The efficiency of each tax can now be gauged by compared its effect on consumer welfare, as given by equation [27] with its effect on the government budget, as given by equation [31]. This involves using the concept of the marginal excess burden.

Marginal Excess Burdens (MEBs)

The marginal excess burden (MEB) of a tax measures the consumer loss per dollar of improvement in the government budget from a small tax rise. The gain to the government budget is returned to the consumer as a lump-sum transfer (“transfer”), so the consumer loss

that is measured only reflects the disincentive or substitution effects from the tax rise, not the income effect. The assumption of a lump-sum transfer to re-balance the budget is a device to allow the efficiency of each tax to be compared on the same footing; it is not intended as a realistic assumption about how government budgets are adjusted in practice.

The loss of consumer welfare from a small rise in a tax can be read from equation [27] while the associated gain to the government budget is read from equation [31]. The ratio of the former to the latter gives the MEB of the tax.

Payroll Tax and Labour Income Tax

Both payroll tax and labour income tax only affect consumer welfare and the budget via their impact on the real after-tax worker wage. Consequently, in the Stylised model these two taxes have the same MEB. Abstracting from a minor adjustment arising from the small differences between M and MC, the MEB for payroll tax and labour income tax can be written as follows.

$$meb(tl, tn) = \frac{\eta \cdot tlab}{1 - \eta \cdot tlab} \quad [33]$$

Here $tlab$ is the tax rate on labour income, when all taxes that ultimately fall on labour are taken into account. From the coefficient on the proportionate change in the real after-tax worker wage in equation [27], these labour taxes include company income tax, labour income tax, payroll tax and part of consumption tax. In calculating the comprehensive tax rate on labour income, the burden of these taxes is expressed relative to the tax base of post-tax labour income.

$$tlab = \frac{CIT + (tl + tn) \cdot w \cdot n + \frac{tc}{1 + tc} \cdot (1 - tl) \cdot w \cdot n}{(1 - tl) \cdot w \cdot n} \quad [34]$$

The MEB for payroll tax and labour income tax arises purely from the disincentive effect of these two taxes on the labour supply. As can be seen from equation [33], the magnitude of this MEB depends on the two factors, η and $tlab$, which enter symmetrically and are now considered in turn.

First, the MEB depends on the size of the existing tax burden on the labour market, as measured by $tlab$. The larger the existing labour market tax burden, the greater the welfare loss from raising an additional dollar of revenue from payroll tax or labour income tax.

Second, the MEB depends on the responsiveness of the labour supply to the worker real post-tax wage, as measured by the compensated labour supply elasticity η . The higher is this elasticity, the greater the welfare loss from raising an additional dollar of revenue from payroll tax or labour income tax.

In CGETAX, the compensated elasticity is based on the widely-cited study of Gruber and Sayers (2002) who find an “elasticity of taxable income” of 0.4. This choice of value is discussed further in section 3.

Equation [33] can also be used to provide a guide to the functional form for the relationship between this MEB and the comprehensive tax rate on labour income $tlab$. Differentiating this MEB with respect to $tlab$ gives the following result.

$$\frac{\partial meb(tl,tn)}{\partial tlab} = \frac{\eta}{(1-\eta.tlab)^2} \quad [35]$$

Thus, for low values of $\eta.tlab$, the slope of the MEB function will approximately equal the compensated labour supply elasticity. However, as $tlab$ increases the curve becomes progressively steeper until the MEB approaches infinity, becoming undefined at,

$$tlab = \frac{1}{\eta}$$

This corresponds to the labour tax rate at which the Laffer curve starts bending backwards. Using the CGETAX value for η of 0.4, this tax rate is 250 per cent, when the tax burden is expressed as a percentage of post-tax labour income. Re-expressing the labour tax rate in the more usual way as a percentage of pre-tax labour income, the Laffer curve tax rate becomes 72 per cent.

Taking a less extreme perspective, consider a relatively high MEB of say 50 per cent. This is reached once the overall labour tax rate, expressed as a percentage of pre-tax labour income, equals 45 per cent.

Consumption Tax

In the Stylised model, consumption tax has a positive MEB, but it is lower than for payroll tax and labour income tax. This is because the tax base, consumption expenditure, is funded from two different sources – labour income and non-labour income. From equation [16] for consumption, these two income sources can be written as follows.

labour income:

$$(1 - tl).w.n$$

non-labour income:

$$tr + [(1 - ta).rm - gr].kd$$

Using equation [16], consumption tax revenue can now be divided into two components, according to the funding source of the consumption expenditure from which it is collected.

$$tc.c = \frac{tc}{1+tc} \cdot \{(1 - tl).w.n\} + \frac{tc}{1+tc} \cdot \{tr + [(1 - ta).rm - gr].kd\} \quad [36]$$

Equation [34] shows that the labour income tax burden only includes the labour-income related component of consumption tax revenue. Consequently it is only this part that has a disincentive effect on the labour supply.

Turning to the component of consumption tax associated with non-labour income, it has no disincentive effect in the Stylised model. It appears in equation [31] as yielding a revenue gain when the rate of consumption tax is increased, but there is no associated welfare loss in equation [27]. Non-labour income includes lump-sum transfers and unsaved post-tax asset income.

This partial funding of consumption expenditure from non-labour income makes consumption tax a more efficient way of raising revenue than payroll tax and labour income tax.

In practice, some transfers are not lump sum. For example, they may be related to labour income as in the case of unemployment benefits. Taking this into account adds further complexity and is outside of the scope of this study.

The formula for the MEB for consumption tax can be derived as follows. As before, the loss in consumer welfare is given by equation [31] and the gain to the government budget is given by equation [27]. In addition, the link from consumption tax to the worker real post-tax wage given by equation [20] also needs to be taken into account.

$$meb(tc) = \frac{\eta.tlabadj}{1-\eta.tlabadj} \quad [37]$$

This takes the same form as the MEB for payroll and labour income of equation [34]. The difference is that the MEB for consumption tax depends on an adjusted form of the comprehensive tax rate on labour income. The adjustment is that the labour tax burden is expressed as a percentage of labour income plus non-labour income, rather than as a percentage of labour income alone. This gives a lower tax rate and therefore a lower MEB in equation [37] for consumption tax compared to equation [34] for payroll and labour income tax.

$$tlabadj = \frac{CIT + (tl+tn).w.n + \frac{tc}{1+tc} \cdot (1-tl).w.n}{(1-tl).w.n + tr + [(1-ta).rm - gr].kd} \quad [38]$$

Company Income Tax

In considering the MEB of company tax, a distinction can be used between company tax raised from normal returns to capital tax and company tax raised from oligopoly rents. Drawing on equation [10], company tax revenue can be divided into the two components of a capital tax and an oligopoly rent tax.

$$tk.rm.k = tk.r.k + tk.ro.k \quad [39]$$

Consider first the MEB for company tax in the absence of oligopoly rents ($ro=0$). In that case, company tax becomes a pure tax on capital. Hence, its MEB is driven by the effect of company tax on the user cost of capital uc . As before, the loss in consumer welfare is given by equation [31] and the gain to the government budget is given by equation [27]. In addition, the link from the user cost of capital to the worker real post-tax wage given by equation [20] also needs to be taken into account.

$$meb(tk_r) = \frac{\eta.tlab + \frac{\sigma}{\alpha}.tke}{1 - \eta.tlab - \frac{\sigma}{\alpha}.tke} \quad [40]$$

Comparing this MEB for a capital tax with the MEB for a labour tax given by equation [33], the MEB for a capital tax is seen to be higher. Both taxes have the same disincentive effect on labour supply. This is because in both cases a tax rise is fully passed on as a fall in the worker real post-tax wage, as shown in the open economy relationship of equation [20].

The difference between a capital tax and a labour tax is that the capital tax also has a disincentive effect on the capital-to-labour ratio. An increase in the rate of capital tax raises the user cost of capital uc , inducing a lower capital-to-labour ratio. In equation [40] for the MEB for capital tax, this capital-labour ratio disincentive effect is captured by the following term,

$$\frac{\sigma}{\alpha}.tke$$

where tke is the effective tax rate on capital, which scales down the statutory tax rate to take into account that depreciation is excluded from the tax base.

$$tke = tk' \cdot \frac{r + tk.r}{\delta + r + tk.r} \quad [41]$$

The strength of the capital-labour ratio disincentive effect from a rise in capital tax is seen to depend on two factors. First, it depends on the effective tax rate on capital, tke . The higher this existing effective tax rate, the higher the consumer loss from raising an additional dollar of revenue from capital tax.

Second, it depends on the elasticity of the capital-labour ratio with respect to the cost of capital. This in turn equals the elasticity of substitution between labour and capital σ , divided by labour's share of income α . Thus, the elasticity of factor substitution drives the strength of the response of the capital-to-labour ratio to a company tax cut. Based on the literature survey of Gunning et al. (2008), elasticities of substitution between labour and capital in CGETAX range from 0.7 to 0.9. This choice of values is discussed further in section 3.

Now consider the MEB for a hypothetical tax on oligopoly rents. Such a tax does not alter the cost of capital uc . Its MEB is derived by using the terms in equations [27] and [31] that involve changes in tk and simplifying.

$$meb(tk_{ro}) = \frac{-kf}{k} \quad [42]$$

An increase in tax on oligopoly rents has an MEB equal to the negative of the share of the capital stock owned by foreign investors. Higher tax on oligopoly rents has no behavioural effects on either foreign or domestic investors. However, the additional tax on foreign investors represents a gain in national income. Thus, there is a gain in consumer welfare equal to the share of foreign-owned capital in the total capital stock. This makes it highly efficient to tax oligopoly rents.

The overall MEB for company tax is approximately equal to a weighted average of the MEBs on the capital and oligopoly rent components of the company tax base.

$$meb(tk) = \frac{r}{rm} \cdot meb(tk_r) + \frac{ro}{rm} \cdot meb(tk_{ro}) \quad [43]$$

This is an approximation because there is also an interaction effect between the taxation of normal returns and oligopoly rents to take into account. When tax on capital is increased, the fall in the capital-to-labour ratio occurs through a fall in foreign investment. The implied fall in the share of the capital stock that is foreign owned leads to a commensurate rise in the local share of oligopoly rents, which represents a gain in national income. This gain in national income is reflected in the following term in the expression for the change in consumer welfare given by equation [27]. This is an interaction effect because it relies on both a response in the capital-to-labour ratio from higher capital tax as well as the presence of oligopoly rents.

$$+\sigma \cdot \theta \cdot \frac{ro}{1 - tk'} \cdot k \cdot \frac{duc}{uc}$$

While a component of company tax may be collected from oligopoly rents, this can never account for all of company tax collections. This is because oligopoly rents refer to returns over and above normal returns to capital and those normal returns are also subject to company tax, as analysed above. Thus, when analysing company tax, the efficiency analysis for capital tax in equation [40] will always be relevant, while the efficiency analysis of equation [42] only needs to be taken into account when oligopoly rents are present.

This analysis indicates that capital tax is highly inefficient while an oligopoly rent tax is highly efficient. Company tax mixes these two taxes together. For a more efficient outcome, it has sometimes being proposed that company tax be replaced by a tax on oligopoly (and other) rents. Alternative rent taxes include a Brown tax, an Allowance for Corporate Capital (ACC) tax and an Allowance for Corporate Equity (ACE) tax, where the alternative taxes are listed in order of decreasing purity but increasing practicality.

The CGETAX model, but not the Stylised model, also incorporates many aspects of the Australian company tax system. These include profit shifting by MNCs and franking credits, which both make company tax even more inefficient, as well the presence in very limited circumstances of foreign tax credits, which make company tax more efficient. These complications are discussed further in section 3 and are taken into account in the CGETAX MEB results presented in section 4.

Saving Extension

The Stylised model is now extended to cover the taxation of asset income, its effects on saving behaviour, and the associated MEB. Saving behaviour is modelled by considering the choice between present and future full consumption in the presence of a tax on asset income at the rate ta .

Full consumption includes both consumption and leisure, as discussed earlier in introducing equations [22] and [23]. Borrowing from the Ramsey model, a representative, infinitely-lived household maximises discounted future utility U from a planned time path of full consumption. Utility at any point in time, or full consumption u , depends on consumption and leisure as presented earlier in this appendix. The size of the household or population is $p(t)$ and grows at the population growth rate of θ .

$$U = \left\{ \int_0^\infty e^{-\rho \cdot t} u \left(\frac{c(t)}{p(t)}, \frac{l(t)}{p(t)} \right)^\varepsilon \cdot p(t) dt \right\}^{1/\rho} \quad [44]$$

The representative household's choice between present and future full consumption is distorted by the tax on asset income at the rate ta . This is reflected in the Euler equation for the optimal rate of growth in aggregate (as distinct from per capita) full consumption grc , which involves the elasticity of intertemporal substitution σt .

$$grc = \theta + \sigma t \cdot [(1 - ta) \cdot rm - \rho] \quad [45]$$

where:

$$\sigma t = 1/(1 - \varepsilon)$$

This same optimal growth rate also applies to the two components of full consumption, consumption and leisure, because $u(.)$ is assumed to be homothetic and the productivity of both work and leisure time are assumed to grow at the same rate γ .

Households are thrifty if the post-tax rate of return to assets, $(1 - ta) \cdot rm$, exceeds their rate of discount of the future, ε . In that case they forego current full consumption in return for future full consumption, so that growth in per capita full consumption is positive i.e. growth in aggregate full consumption exceeds growth in the population θ . The extent of this growth in per capita full consumption is proportional to the elasticity of intertemporal substitution.

Thus, the value of the elasticity of intertemporal substitution determines the strength of the saving disincentive effect when asset income is taxed.

To obtain the path for full consumption, the national intertemporal budget constraint is required. Starting with the dynamic form of equation [14], the intertemporal budget constraint can be written as follows, where w^* was defined in equation [29] and represents the real wage facing producers, inclusive of company tax per worker.

$$\dot{kd} = rm.kd + w^*.T - (c + w^*.l) \quad [46]$$

Equation [46] is a first order differential equation for the real stock of locally-owned capital. In it, T and g grow with the economy at the rate gr ($=\theta+\gamma$), and from equation [45] $c+w^*.l$ grows at the rate grc . With an initial domestic capital ownership of $kd(0)$, the initial level of $c+w^*.l$ is solved to be the following, where other variables are also at their initial values.

$$(c + w^*.l)(0) = \frac{rm-grc}{rm-gr} . M \quad [47]$$

where:

$$M = (w^*.T - g) + (rm - gr).kd(0) \quad [48]$$

We can use this solution for $c+w^*.l$ to solve for lifetime utility U using equation [44]. This gives a solution for lifetime utility of the following form, where z is independent of ta .

$$U = z . M . \frac{rm-grc}{rm-gr} . (\{1 - ta\} . rm - grc)^{\frac{\sigma t}{1-\sigma t}} \quad [49]$$

In the above, the growth rate for consumption and leisure of grc can differ from the growth rate for the economy generally of gr . The common simplifying assumption is now made that these two growth rates are the same in the baseline scenario. This involves calibrating the discount rate ρ as follows, where ta and rm are set to their baseline values.

$$\rho = (1 - ta).rm - \frac{\gamma}{\sigma t} \quad [50]$$

The equality between grc and gr is only enforced in the baseline scenario.

When ta is increased to estimate the MEB for asset income tax, this will reduce grc in equation [45], taking it below gr .

$$\frac{\partial grc}{\partial ta} = -\sigma t . rm \quad [51]$$

To derive the MEB for asset income tax, we need lifetime utility as given by equation [49], and we also need a formula for asset income tax revenue. Obtaining the latter is complicated by the fact that when full consumption grows at a different rate from the economy generally, so will asset income tax revenue. To put asset income tax collections on the same footing as

other tax collections, we need to allow for the time value of money. This is done by modelling them as their equivalent perpetuity, where the perpetuity in question grows at the same rate as the economy. This leads to the following formula for asset income tax collections, $tarev$.

$$tarev = ta.rm. \left[kd(0) + M. \frac{grc-gr}{(rm-grc).(rm-gr)} \right] \quad [52]$$

In the simple case of the baseline scenario where $grc=gr$, then

$$tarev = ta.rm.kd(0)$$

In this simple case, the perpetuity equivalent of collections matches their initial level.

A similar issue arises with modelling full consumption. Because it may grow at a different rate from the economy, its initial level relative to other economic variables will not be representative of its relative level later on. To correct for this, the equivalent perpetuity is again used. This means replacing the initial level for $c+w*.l$ given by equation [47] with its perpetuity equivalent.

$$c + w*.l = M \quad [53]$$

The above takes us back to the static budget constraint of equation [28]. Indeed, in the end, the intertemporal modelling in the saving extension only involves two modifications to the core model. First, it involves adopting a measure of lifetime utility as indicated by equation [49]. Second, it involves adopting the new formula for asset income tax collections given by equation [52]. These are the only two modifications that are required to be able to analyse changes in the rate of asset income tax ta and the associated MEB.

The MEB for a small increase in asset income tax can be obtained using the following formula.

$$meb(ta) = \frac{\frac{\partial U}{\partial ta} / \frac{\partial U}{\partial M}}{\frac{\partial tarev}{\partial ta}} \quad [54]$$

The numerator measures the loss in consumer welfare as the permanent income compensation that is needed to keep lifetime utility unchanged. The denominator is the perpetuity equivalent of the gain to the government budget.

Obtaining the derivatives in the MEB formula of equation [54] from equations [49] and [52] and simplifying gives the formula for the MEB for asset income tax.

$$meb(ta) = \frac{\sigma.ta.\frac{rm}{(1-ta).rm-gr}}{\frac{(rm-gr).kd}{M} - \sigma.ta.\frac{rm}{rm-gr}} \quad [55]$$

This MEB reflects a saving disincentive effect driven by the product of the elasticity of intertemporal substitution (EIS) and the asset income tax rate. However, the MEB for asset income tax is also affected by the narrow base of asset income tax. Asset income tax induces substitution of present full consumption for future full consumption. Yet its tax base is asset income, which accounts for only a small share of the funding of full consumption, as reflected in the following term in the denominator of the MEB formula.

$$\frac{(rm - gr).kd}{M}$$

This makes asset income tax potentially an inefficient tax unless applied at a suitably low rate.

In the above, the strength of the saving incentive effect also depends on the elasticity of intertemporal substitution (EIS). The EIS is set to 0.25 in CGETAX. This choice is discussed in section 3.