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Tax mix change to reduce greenhouse gas emissions*

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A pollution tax or emissions trading scheme places a price on greenhouse gas emissions. This price also is an additional indirect tax and a government revenue windfall. To restore distributional equity, to avoid compounding the efficiency costs of existing distorting taxes and to maintain macroeconomic stability, it is argued that most of the revenue windfall be recycled to households as lower income tax rates and higher social security payments. As the carbon price rises over time, new and larger tax mix change packages will be required.

Key words: greenhouse gasses, pollution, taxation reform.

1. Introduction

Placing a price on greenhouse gas emissions, either through a tax or through a tradable permit scheme, is a cost-effective way to internalise the external pollution cost of greenhouse gas emissions (Hepburn 2006; Kolstad 2009). For government, the policy intervention represents an increase in the aggregate indirect tax burden, which provides a windfall revenue gain. Most of the additional indirect tax is passed forward to consumers as higher prices. As well as increasing the relative prices of greenhouse-gas-intensive products and production processes, a price on carbon increases the average cost of living.

The higher average consumer price effects of a price on carbon are regressive, they compound the distortions caused by current income and consumption taxes on decisions to work and save by households, and they provide incentives for employees and investors to seek compensating increases in nominal wages and interest rates. Returning most of the indirect tax revenue windfall to households as a component of a policy package which is approximately aggregate revenue neutral and vertical distribution equity neutral largely can eliminate these undesired effects. Such a tax mix change package also may improve political acceptance of an explicit price on carbon.

Most of the debates in Australia on policy design to place a price on greenhouse gas emissions propose to return only some of the revenue windfall gain to households. For example, Garnaut (2008) and the government-proposed

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Carbon Pollution Reduction Scheme (CPRS) (Department of Climate Change 2008) propose to return about a half of the revenue to households and then only as compensation to low-income households. Another option for households seeking compensation for the higher cost of living is through higher wages and nominal interest rates. A new tax system (ANTS) tax reform package of 2000, which involved a similar net increase in indirect taxation, avoided increases in wages and interest rates and the associated risk to macroeconomic stability by returning the revenue gain, and more, as reductions in income tax and increases in social security payments to compensate all households for the estimated higher cost of living. An explicit price on carbon as an increase in indirect taxation, with no changes in other taxes, would compound distortions associated with the current income and consumption taxes. This effect has been the focus of discussions about environmental taxation and the double dividend (Parry *et al.* 1998; Bovenberg and Goulder 2002; and Bovenberg *et al.* 2008). Designing a tax mix change package to minimise unintended second-round tax efficiency losses is an important neglected topic.

All proposals to date to reduce greenhouse gas emissions include a gradual reduction in the aggregate pollution quantity over the next 40 years with rising carbon prices. The assertion in the study of Garnaut (2008) and implicit assumption in Treasury modelling (The Treasury 2008) that the net government revenue windfall and increase in the cost of living will be a one-off effect is valid only if the elasticity of the marginal abatement cost function is unity. Available evidence supports an inelastic function. Then, projected increases over time in the price of carbon will result in increases over time in the revenue gain and in the average cost of living. This, in turn, points to a policy strategy of a sequence of tax mix change packages, rather than a one-off package.

2. Placing a price on carbon

The aim of placing a price on carbon is to internalise the external costs of the pollution, which, with a high probability, contributes to the external costs of climate change in future. An emissions or carbon tax imposes a direct cost on pollution, and the market response determines the quantity reduction of pollution. A cap-and-trade or tradable permit scheme, such as the proposed CPRS or the European emissions trading scheme, sets the quantity pollution reduction, and the market determines the price for the newly created scarce property right to pollute. Under conditions of perfect knowledge and certainty, the two options have the same price and quantity outcomes. In the realistic context of imperfect knowledge and evolving economic circumstances, the two options have different outcomes and properties and different pros and cons (see, for example, the studies of Hepburn 2006; Kolstad 2009). While clearly important issues, the arguments discussed here are not materially affected by the exact mechanism chosen to impose a price on carbon.

About 70 per cent of Australian greenhouse gas pollution comes from the combustion of fossil fuels in the production of electricity and other stationary energy and for transport (Department of Climate Change 2006). The other major source of greenhouse gas emissions associated with agriculture is not considered because of unsolved challenges in measurement. About 1000 businesses would bear the initial burden, or statutory incidence, of a price on carbon levied on the combustion of fossil fuels (The Department of Climate Change 2008).

Consider next the economic incidence of a price on carbon on the combustion of fossil fuels. For reasons of simplicity and low transaction costs, the use of petroleum products is measured upstream at the production and import of refined product stage, building on the existing petroleum products excise. This is a consumption base. Given that Australia is a price taker in a large global market for petroleum products, the extra cost of a price on carbon would be fully passed forward as higher prices to domestic business and household buyers. Studies of tax incidence of excise by ABS (2007) and Warren *et al.* (2005), and ACCC inquiries into the pricing of petroleum products, support the full pass-through logic for petroleum products.

The electricity generation industry is a non-traded industry and one with different technologies. Electricity production has a consumption base, and market prices respond to production costs, including a price on carbon. However, because of the different technologies, the relevant marginal producer in terms of carbon intensity varies over time and with circumstances. Electricity is a non-storable product facing variable demand over the day and across seasons. Generation technologies vary in terms of carbon and pollution intensity, levels of and mixture of fixed and variable costs, and ease of adjusting production quantity over time. If the most pollution-intensive fuel coal was always the marginal producer, costs of a price on carbon on coal-fired electricity would be fully passed forward, and non-coal generators would make net gains. Coal provides 84 per cent, and gas 9 per cent, of generated electricity. This suggests that for most of the time, coal would be the marginal supplier and that close to 100 per cent of a carbon price at proposed levels of \$20–40 per tonne of CO_2-e would be passed through to buyers as higher prices. This outcome is supported by the simulations of Menezes *et al.* (2009). Even though Europe is far less dependent on fossil fuels for its electricity than Australia, <60 per cent, Sijm *et al.* (2006) estimate that between 60 and 100 per cent of the market price of tradable permits is passed forward as higher electricity prices.

To the extent that <100 per cent of the carbon price on coal is passed forward to buyers as higher electricity prices, coal-fired generator asset values fall. But, at the same time, asset values of gas and non-renewable generators rise, and many energy companies hold a portfolio of asset types. Then, the net company asset effect can be positive or negative. While the CPRS (Department of Climate Change 2008) proposed compensation, Garnaut (2008) argued against. Garnaut noted a general (but not universal) Australian policy to not compensate asset owners for falls in capital asset values as a result of policy changes, including reductions in tariffs; and that the prospect of a carbon price had been known for at least the last two decades. In addition, given that capital to finance new and lower pollution electricity generation is part of a global capital market, and not just from the balance sheets of current Australian generators, industry claims that compensation of existing asset owners is necessary to fund new investments is not a compelling argument.

In 2006–2007, 30 per cent of refined petroleum products and 23 per cent of electricity were directly consumed by households (ABS, 2009). The majority of both petroleum products and electricity are used as intermediate inputs by all other industries. A price on carbon is passed forward as an increase in the cost of these intermediate inputs. For these other businesses, the tax base is a production base falling on exports and excluding imports. If there is a global agreement, a production base rather than a consumption base means most of the extra production cost can be passed on to buyers. Models with a fully pass-forward framework used to estimate price changes with the 2000 ANTS changes in indirect taxation with a consumption base were very close to actual outcomes (see, for example, The Treasury 2003; Valadkhani 2005).

But, if Australia places a price on carbon before most of the countries from whom it imports and to whom it exports, producers in the Australian energy-intensive trade-exposed industries (EITE) will be unable to pass on all of the higher costs of electricity and petroleum product inputs. However, some of the cost increase will be passed on because of product heterogeneity, especially with respect to import substitutes (Coutts and Norman 2007), and because of less than perfectly elastic export demands. Also, maintaining a balance of payment equilibrium means that a fall in exports and a rise in imports will induce a depreciation of the exchange rate and partially compensate the first-round profit squeeze on the EITE. Daley and Edis (2010) estimate the export and import quantity effects for most of the EITE will be small. To reduce ‘carbon leakage’ and unnecessary restructuring of the EITE, Garnaut (2008), the CPRS (Department of Climate Change 2008) and others propose providing transitory compensation to these industries for higher input costs. In the early years, the assistance payments are estimated at about 30 per cent of the indirect tax revenue windfall. As other countries join and the world prices for the EITE rise, so also do prices for these goods to Australians. In effect, the share of the windfall revenue gain available for compensating households rises with the rise in the average cost of living, while that required for transitory compensation of the EITE falls.

The focus of the rest of the paper is on the share of an explicit price on carbon passed forward to households as higher prices. Modelling undertaken by the Garnaut Review (Garnaut 2008) and Treasury (The Treasury 2008) provide indicative estimates of changes in relative prices at the consumer level and in the average cost of living. For a carbon tax or tradable permit price of around \$25 a tonne of CO_2-e, electricity prices are estimated to rise by 18 per cent, gas by 12 per cent and clothing by < 1 per cent, and the consumer price index (CPI), or average cost of living, to increase by 1.1 per cent. The paper turns to the economic arguments for using the revenue windfall from the increase in indirect taxation to fund compensation to households for the increase in their average cost of living.

3. Distributional equity

Available evidence is that the increase in aggregate indirect taxation associated with a price on carbon will be regressive in its effects (for Australia, Cornwall and Creedy 1996; The Treasury 2008; and for the US, Metcalf 2009). Household energy outlays, particularly on electricity, gas and petroleum products, and on other products with a high share of energy inputs, including food, represent a higher share of expenditures for households at the lower end of the income distribution. In addition, The Treasury (2008) argue that on average, lower-income households have lesser substitution options, or more inelastic demands, for the relatively energy-intensive products than higher-income households. Within each category of household, the magnitude of the expenditure cost increase of the explicit cost placed on pollution varies from the average with differences in individual preference functions and constraints. For cross-sectional data, lower-income households are observed on average to have much lower if not negative saving rates when compared with middle-income and especially high-income households (ABS 2006).

One aim of a tax mix change package is to use the revenue windfall from the emissions trading scheme or carbon tax to fund reductions in other taxes on households so that their overall effective consumption capacity or purchasing power approximately is maintained. Refunding the indirect tax revenue windfall as lower other taxes on households might take one of several options. One option is to lower the rate of the broad-based goods and services tax (GST). It has the advantage that it uses consumption rather than income for the tax reduction, and this automatically provides a relatively neutral aggregate tax burden for households with different savings propensities. On the other hand, a lower GST as a flat rate consumption tax provides roughly equal tax reductions for high- and low-consumption households, and it would not fully compensate the regressive effects of the higher price on carbon. A second option is to reduce income tax rates in such a way as to roughly maintain the average aggregate income plus indirect tax rate. This option was followed with the introduction of a GST in New Zealand in 1985, and its increased rate in 2010, and in Australia in 2000. In principle, the regressive effects of a price on greenhouse gas pollution and differences in savings rates can be incorporated in a tax mix change package of more indirect taxation and less income taxation, which approximately is both revenue neutral and distributional neutral.

Consider the details of a tax mix change package for the Australian income transfer system. In the case of social security payments automatically indexed to the CPI, which includes most of the family payments and allowances for the unemployed and sick, so long as the CPI base closely represents the purchase patterns of these recipients, compensation is automatic, although with a 6-month lag. Detailed ABS studies indicate some divergence between the general CPI and the CPI for pensioners and beneficiaries (ABS 2010b), but also that because of the fixed base period weights, the CPI results in a similar order of upward bias by ignoring substitution among products in response to changes in relative prices (ABS 2011). For other social security payments indexed to a measure of wages, which includes most of the pensions for the aged, those with a disability and single parents with young children, and assuming no independent wage response to the increase in indirect taxes, a compensating increase in the pension rates would be required to retain distributional equity.

Australia has a progressive personal income tax rate schedule with a zero-rate threshold. Consider first a required increase in the tax-free threshold from the current level a to a′. For an increase in the indirect tax rate of $\Delta t_{\mathrm{i}} = t'_{\mathrm{i}} - t_{\mathrm{i}}$, the new threshold should equate the increase in the indirect tax collected of $\Delta t_{\mathrm{i}}(\mathrm{a}' - S)$ with the reduction in income tax collected of $(\mathrm{a}' - \mathrm{a})t_{\mathrm{y}}$, where t_{y} is the first non-zero marginal tax rate and S is aggregate saving (which may be positive or negative). Solving for aggregate tax revenue neutrality, the new income tax-free threshold is

$$a' = (\mathrm{a}t_{\mathrm{y}} - \Delta t_{\mathrm{i}}S)/(t_{\mathrm{y}} - \Delta t_{\mathrm{i}}). \quad (1)$$

The tax-free threshold is pushed higher; the greater the explicit charge on pollution and increase in indirect tax, the lower the sum saved, and the lower the first non-zero marginal income tax rate. Note that all households with a taxable income below the new threshold a' will not be fully compensated.

For the non-zero marginal income tax rate brackets, vertical equity requires a lower marginal income tax rate, Δt_{y}, to match the higher indirect tax burden with the price on carbon, Δt_{i}. The current income tax plus indirect tax burden is $t_{\mathrm{y}} + (1 - t_{\mathrm{y}} - s)t_{\mathrm{i}}$, where $s = S/Y$ is the marginal saving rate (which again may be negative or positive). With the higher indirect tax rate t'_{i} and lower marginal income tax rate, t_{y}', the aggregate tax burden becomes $t_{\mathrm{y}}' + (1 - t_{\mathrm{y}}' - s)t'_{\mathrm{i}}$ Equating the two, the required reduction in the marginal income tax rate, Δt_{y}, is

$$\Delta t_{\mathrm{y}} = -(1 - t_{\mathrm{y}} - s)\Delta t_{\mathrm{i}}/(1 - t'_{\mathrm{i}}). \quad (2)$$

The marginal income tax rate reduction will be greater; the larger the increase in the average consumer price, or indirect tax rate, with the pollution charge, the smaller the saving rate or the larger the dis-saving rate, and the smaller the initial marginal income tax rate.

An illustration of an approximate revenue neutral and vertical equity distribution neutral package for Australia in 2010–2011 involving a higher indirect tax burden associated with an explicit price on carbon and a lower personal income tax rate schedule is given in Table 1. The current personal

Table 1 Illustration of a tax mix change package personal income tax rate schedule

2010–2011 effective income tax rate schedule		Approximate revenue and distributional neutral package	
Taxable income in \$000's/year	Marginal tax rate in %	Taxable income in \$000's/year	Marginal tax rate in %
0–15	0	0–17.3	0
15–30	15	17.3–30	13.27
30–37	19	30–37	17.78
37–67.5	34	37–67.5	32.99
67.5–80	30	67.5–80	28.93
80–180	37	80–180	36.36
> 180	45	> 180	44.44

2010–2011 schedule based on Swan and Tanner (2009, p. 5.24). Package assumes carbon price raises average cost of living, or Δt_i, by 0.02 for income up to \$30,000, then 0.015 for income up to \$80,000, and 0.01 for > \$80,000, and apply (1) and (2) of text with *S* and *s* equal to zero.

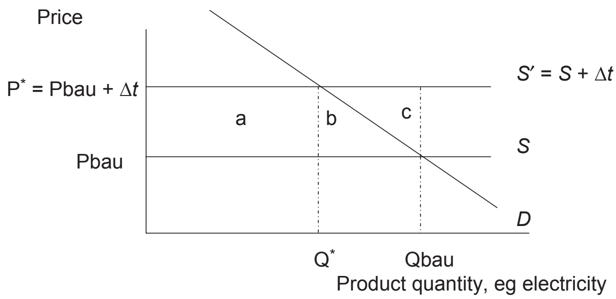

Figure 1 Market for a pollution intensive product.

income tax rate schedule has an effective tax-free threshold of \$15,000 with the low-income tax offset, and then six non-zero marginal tax rate brackets. It is a progressive rate schedule. Suppose a carbon tax of about \$25 a tonne of CO_2-e fully passed forward results in a regressive pattern of average price increases of 2 per cent for low-income individuals (< \$30,000 a year), 1.5 per cent for middle-income individuals (\$30,000–\$80,000 a year) and 1 per cent for high-income individuals (> \$80,000 a year). Formulas (1) and (2) are used to calculate the modified income rate schedule in the second column.

The package collects less income tax revenue to offset the increase in indirect taxation, and it is more progressive. Specifically, the tax-free threshold is raised by \$2,300, and the marginal tax rates are reduced by about 1.7 percentage points in the second tax bracket down to just over 0.5 percentage points in the top income bracket.

Another way to consider the design of a tax mix change package is via a partial equilibrium model of the market for one of the pollution-intensive goods or services as shown in Figure 1. In the initial state, supply, *S*, is assumed perfectly elastic and with demand, *D*, consumption is Qbau and price Pbau.

The price on greenhouse gas pollution, or increase in indirect tax, at rate Δt is fully passed on with a new equilibrium at Q* and P*. The windfall indirect tax revenue gain is area 'a'. Given that the CPI is a base period quantity or Laspeyres index, those given CPI compensation, including social security benefits with automatic indexation to the CPI and income tax reductions using $\Delta t_i = \Delta CPI$ in (1) and (2), receive area 'a + b + c'. Note that they are over-compensated by area 'c' and that there is a net budget cost of area 'b + c'. The over-compensation is greater; the greater the extent to which households replace pollution-intensive products with pollution-extensive products. An aggregate tax revenue neutral package would leave consumers with a net loss of area 'b', but they would gain from lower costs of adaptation to a smaller level of climate change not shown in this figure.

Using the Slutsky equation model, the proposed household compensation package still will reduce greenhouse gas pollution. Return of the extra indirect tax revenue to households would offset most of the income effects of the price on carbon to reduce greenhouse gas pollution. The substitution effects of higher relative prices of greenhouse-gas-intensive products remain to provide incentives and rewards to replace greenhouse-intensive products with greenhouse-extensive products. The relative price changes driving the substitution effects are much greater in magnitude compared with the income effects together with the low income elasticity for emissions-intensive products. For example, for a \$25/tonne of CO_2 tax, The Treasury (2008) estimate relative price increases for electricity and gas of 18 and 12 per cent, respectively, and of income compensation of 1.1 per cent.

This section highlights strong limitations to the design of a tax mix change package if it is to be both approximately aggregate revenue neutral and maintain vertical equity. Arguably, the Garnaut (2008) and CPRS (Department of Climate Change, 2008) proposals fail the design constraints. First, they propose to reallocate only a half of the indirect tax revenue windfall to households. Even with a carefully designed 100 per cent recycling of the revenue to households, there will be some losers, including those with low taxable incomes and those with above-average energy consumption bundles; and there will be some winners. Second, middle- and higher-income households also need compensation, although a lesser share as a per cent of income. Third, the CPRS proposal to provide more than CPI indexation to social security recipients would over-compensate many.

4. Tax efficiency arguments

Existing taxes distort factor supply, product choice and business organisation decisions, and they incur efficiency costs. Placing a price on carbon as an increase in indirect taxation with no changes in existing taxes compounds the distortions and efficiency costs of the existing taxes. Using the revenue windfall from the price on carbon to reduce existing distorting taxes can offset this compounding effect. Then, a tax mix change package can reap the efficiency dividend of correcting the external cost market failure without compounding distortions caused by existing taxes.

Taxation in Australia in aggregate takes about 30 per cent of GDP. The most important revenue sources are a progressive rate income tax at 59 per cent of all revenue, the GST with 12 per cent and other indirect taxes 13 per cent (ABS 2010a).

Existing taxes place a wedge, T, between the price paid by the buyer and the return received by the seller in factor and product markets and result in smaller quantities bought and sold. Consider the example of labour and distortions to the decision to work (and purchase market goods and services) versus leisure (and home production). Both income tax and indirect tax reduce the goods and services an employee can purchase from the market for a period of work, or the real wage. Assume for simplicity that all after-income-tax income is spent, the tax wedge can be expressed as

$$T = W[t_{\mathrm{y}} + (1 - t_{\mathrm{y}})t_{\mathrm{i}}], \quad (3)$$

where W is the market wage and t_{y} and t_{i} are the marginal rates of income tax and indirect tax, respectively. The tax wedge T of (3) favours substitution from paid work (and market-purchased goods and services), which is taxed, to non-taxed leisure (and home production).

The tax-induced quantity reduction involves an efficiency loss. For an individual factor market, such as for labour, the efficiency cost or deadweight loss of a tax wedge T can be expressed as

$$\mathrm{DWL} = 0.5\Delta QT = 0.5[(\varepsilon\eta)/(\varepsilon + \eta)]\mathrm{NW}t^2, \quad (4)$$

where ΔQ is the change in quantity, T is the tax wedge of (3), ε is the (absolute value) elasticity of demand, η is the elasticity of supply, NW is the market wage bill or income for employment of N and a wage of W per unit employment and t = T/W is the tax wedge rate. Note that the efficiency cost rises with the square of the tax rate and with the elasticities of labour demand and supply.

How does the introduction of a price on carbon compound existing tax distortions?

As argued in section 2 above, most of a price on carbon, as an additional cost of production, will be passed forward to households as higher prices than otherwise. Effectively, the indirect tax burden is increased to $t_{\mathrm{i}}' = t_{\mathrm{i}} + \Delta t_{\mathrm{i}}$ where Δt_{i} is the pass-through price increase effect of the carbon price expressed as an increase in the indirect tax rate equivalent to an increase in the average cost of living. At the same time, t_{y} and t_{i} are unchanged. Then, a price on carbon increases T in (3). From (4), the higher T increases the efficiency cost of income and indirect tax distortions to the labour market. Available estimates of the efficiency costs of Australian taxation, as for other countries, are large. Of course, there are a range of estimates, and the actual magnitudes vary with specific models and key elasticities used. The Henry Review of Taxation (Henry *et al*. 2010, p. 13) report estimates of the marginal cost of another dollar of taxation revenue for different taxes based on a computable general equilibrium model. The marginal efficiency cost approximately is the derivative of (4) with respect to the tax rate t divided by the derivative of tax revenue, tNW, with respect to the tax rate t. The marginal efficiency cost of taxation of labour income discussed above is about 25 cents. This is the compounding of distortions, or the tax interaction effect, of an environmental tax. As argued by Bovenberg and Goulder (2002) and other critics of the double dividend hypothesis with taxation of environmental external costs, this additional efficiency loss can be as great as, or greater than, the efficiency gain from placing a price on carbon to reduce the market failure external cost of greenhouse gas emissions pollution.

However, government can use the revenue windfall of the carbon tax or returns from the auctioning of tradable permits to fund a reduction in existing income or other indirect taxes. An approximate revenue neutral reduction in the income tax rate, Δt_{y}, which leaves T in (3) unchanged, can be derived as

$$\Delta t_{\mathrm{y}} = -[(1 - t_{\mathrm{y}})\Delta t_{\mathrm{i}}]/[1 - (t_{\mathrm{i}} + \Delta t_{\mathrm{i}})]. \tag{5}$$

To illustrate, for a current marginal income tax rate $t_{\mathrm{y}} = 0.3$ and indirect tax rate $t_{\mathrm{i}} = 0.1$, and the net average consumer price increase of $0.01 = \Delta t_{\mathrm{i}}$ for about a \$20/tonne CO_2-e carbon price, the income tax rate would be reduced to 0.292 or just under a percentage point.

To avoid compounding the efficiency costs of distortions of existing income and indirect taxes, all of the revenue associated with the share of the price on carbon passed forward to households would have to be returned as reductions in other taxes on all households making decisions about work and saving. This means more than the 50 per cent proposed by Garnaut (2008) and the CPRS (Department of Climate Change 2008), and that the compensation go to high- as well as low-income households.

5. Macroeconomic stability

Another argument for a tax mix change which reallocates the revenue windfall from a price on carbon to compensate households through lower income tax is to avoid adverse macroeconomic outcomes. With constant nominal labour and capital incomes, and constant income and other indirect tax rates, the rise in living costs associated with a price on carbon reduces the real purchasing power of owners of both labour and capital. One option is for workers to seek compensating increases in market wage rates to restore real wages and for owners of capital to seek increases in nominal interest rates to restore real interest rates (and required rates of return on other forms of wealth). Compensating increases in remuneration at the same time raise production costs. In turn, businesses seek compensation for higher production costs by raising product prices. Then, the net increase in indirect taxation associated with a carbon tax or an emissions trading scheme could initiate a vicious price-wage inflationary spiral.

A policy strategy along the lines of the tax mix change packages associated with the introduction of the GST in Australia in 2000, and in New Zealand in 1985, and a further increase in 2010, is envisaged. Descriptions and evaluations the effects of the earlier schemes are in The Treasury (2003) and in the study of Valadkhani (2005) for Australia, and in the study of Stephens (1989) for New Zealand. These packages involved two key ideas to sustain low inflation. With the Australian 2000 tax reform package, the higher cost of a net increase in indirect taxes (the 10 per cent GST less replacement of the WST and some state indirect taxes leaving a net increase in indirect taxes raising living costs by about 2 per cent, which would be comparable to a price on carbon of $30–35 per tonne of CO_2-e) was compensated by reductions in income taxation (and increases in social security payments). In Australia, most households were over-compensated at a net cost to the budget. Second, complementary policy initiatives, including jawboning and prices surveillance, argued that the estimated one-off increase in the cost of living associated with the increase in indirect taxation should be discounted in wage negotiations and interest rates, for example, by the central banks and wage setting bodies. In practice, there was a one-off blip in measured inflation, and nominal wage and interest rates followed normal paths.

To be effective in avoiding an unwanted stimulus to inflation, it is important that the income tax reductions be directed at incomes at all levels and to capital as well as labour incomes. The focus of household compensation to those on low incomes proposed by Garnaut (2008) and the government CPRS (Department of Climate Change, 2008) would not be enough. Metcalf (2009) in discussing a carbon tax for the United States explicitly argues, as here, the case for compensating capital as well as labour income.

Rather than reducing income tax rates, an alternative and more direct compensation package would use the revenue windfall from the price on carbon to reduce other indirect taxes, such as the GST or payroll tax. This option has the advantage of directly offsetting the increase in the average price level for households and reduces the need for government jawboning to discount general price increases in setting wages and interest rates. But, as noted in section 3 above, the reduction in other indirect taxes option is less effective in restoring vertical equity relative to the option of increasing social security payments and reducing income taxation.

6. A sequence of tax mix change packages

Available policy statements and model analyses of policy options to reduce greenhouse gas emissions anticipate a path of higher per unit pollution charges for at least the next 50 years. The price per unit of pollution will rise over time either as the aggregate permit quota falls or explicitly with a time path of rising tax rates to achieve the same effect. For example, the proposed CPRS envisages reducing aggregate economy emissions below 2000 levels by between 5 and 25 per cent by 2020 and by 60 per cent by 2050. With expected growth in both per capita incomes and population (Swan 2010), the reductions in pollution per capita and per dollar of GDP will be even larger. Garnaut (2008) and The Treasury (2008) in their modelling to meet the CPRS quotas use a real annual growth rate of permit prices of 4 per cent. Other models, for example, Stern (2006), Nordhaus (2008) and Metcalf (2009), explicitly or as a consequence of their specified models, project a path of rising costs per unit of greenhouse gas emissions.

Discussing the implications for inflation of placing a price on carbon, both Garnaut (2008) and The Treasury (2008) contend that there will be only a one-off blip to inflation even though the price of permits is projected to increase at around 4 per cent real per year. Garnaut (2008, p. 568) states

> The introduction of carbon pricing will generate a once-and-for-all increase in the general price level.

and the Treasury (The Treasury, 2008, p. xv) evaluating the CPRS projects

> … a one-off rise in the price level of around 1–1.5 per cent is expected, with minimal implications for ongoing inflation.

These claims require that the price elasticity of the marginal abatement cost function (defined as the percentage change in pollution quantity for a 1 per cent change in the price of pollution) just equals unity. Then, a higher price on carbon reduces pollution to such an extent that the revenue windfall remains constant, and if extra costs are fully passed forward, the net increase in consumer outlays or costs of living will be unaffected.

On the other hand, if the marginal abatement cost function is inelastic for price increases projected over the next few decades, higher prices will result in increases in government windfall revenue and higher average costs of living. In turn, the higher cost of living and further aggravation of distortion costs of existing taxes provide justifiable arguments for using the additional revenue windfall to augment the compensating reductions in income tax and increases in social security payments for households and vice versa for an elastic function.

Further, if Australia places a price on carbon before some other countries and many of these countries in due course join a global trend to carbon pricing, compensation to Australian EITE can be phased out as proposed. At the same time, consumer prices of trade-exposed goods and services, as well as of non-traded products, also increase to reflect their direct and indirect carbon content. That is, as transitory assistance to the EITE is phased down, the share of the indirect tax revenue windfall passed forward to domestic households as higher prices increase and the average cost of living increases towards 100 per cent of the government revenue windfall gain.

The effects of higher consumer prices for greenhouse-gas-intensive products on household expenditure can be illustrated with a simple model. Suppose just one good is greenhouse gas intensive, good one, and faces a higher price, dP_1, while the prices of the other greenhouse-gas-extensive goods for $j = 2, 3, \ldots, n$ do not change. For household expenditure, $E = \sum P_i Q_i$, taking the total differential, the effect of dP_1 on expenditure can be expressed as

$$dE = [1 + e_{11} + \sum e_{j1}(w_j/w_1)]Q_1 dP_1 \quad (6)$$

where e_{11} is the price elasticity of demand for product i with respect to the price of product 1 and w_i represents the share of product i in total expenditure. Consider some special cases of (6). The CPI with a base of initial period weights implicitly assumes the elasticity terms e_{11} equal zero, and so consumer outlay unambiguously rises, and by Q_1 dP_1. If the cross-price elasticities are zero, then a rise in P_1 results in an increase in expenditure if the own price elasticity for good one is inelastic and a fall if it is elastic. In the more likely case that some of the other products are substitutes for product one, the larger the degree of substitutability, the larger e_{j1}, and then expenditure E may fall even when the own price elasticity is elastic.

Estimates of the elasticity of demand for the marginal abatement cost function from modelling by the Treasury for Australia and used by Garnaut for permit prices and pollution reduction over the 2020–2050 period (The Treasury (2008), Table 6.1 for prices and Table 6.8 for quantities) indicate values around −0.5 for the three models used. Metcalf (2009) for the United States estimates that a carbon tax rising from US\$15/tonne of CO_2-e in 2015 by 4 per cent real per year to US\$60/tonne of CO_2-e in 2050 would generate revenue doubling as a share of GDP from 0.66 per cent to 1.15 per cent.

Clearly, there is uncertainty about the elasticity of the marginal abatement cost function. Therefore, the magnitudes of effects of anticipated increases in the permit price or carbon tax on the average cost of living and the government indirect tax revenue also are uncertain. The elasticity reflects the combination of consumer demand elasticities for carbon-intensive products, the substitutability of energy intensive and energy-extensive business production processes, the substitutability of different forms of energy production, and also the opportunities and costs of carbon sequestration. Importantly, technology is certain to develop and affect each of these key parameters in ways not now understood, let alone quantified. Collecting and monitoring information to support adaptive decision-making, including the design of the tax mix change package, will be important.

If the marginal abatement cost function is revealed to be inelastic, both the government revenue windfall and the average cost of living will rise over time.

Granted the uncertainty, and with incoming information, a sound policy strategy would anticipate renegotiating every few years an explicit recycling of most of the additional indirect tax revenue windfall gain to households as additional compensating reductions in income taxation and increases in social security benefits.

7. Conclusions

There are compelling economic and political arguments to devise a tax mix change package as a comprehensive policy to place an explicit and transparent price on carbon. Recycling the windfall government revenue gain from the effective increase in indirect taxation to households is necessary to: restore the status quo equity of the aggregate tax burden; avoid compounding distortions and efficiency costs of existing taxes while reaping the efficiency gain of reducing pollution; and avoid initiating an inflationary spiral. Such a package will require most of the revenue windfall and at least all of that passed forward to households as higher prices. The compensation has to extend across all citizens as increases in social security payments and as reductions in income taxation with a more progressive rate schedule. The proposals by Garnaut (2008) and the CPRS (Department of Climate Change 2008) to use only about a half of the revenue gain for compensation, and then to focus on low-income households, will not offset the second-round adverse effects of a price on carbon.

Projected increases in the carbon price, together with the likely inelasticity of the marginal abatement cost function, will generate over time an increase in government indirect taxation revenue and higher increases in the average cost of living. Then, with the benefit of forthcoming information, every few years, a new tax mix change package to recycle to households the additional revenue windfall will be required.

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