Chapter 27

Taxation and Efficiency

There can be no economy where there is no efficiency.

Disraeli, Letter to Constituents

The Deadweight Loss of Taxation ♦ Taxation of Labour Income ♦ Taxation of Income from Capital ♦ Selective Commodity Taxes ♦ General Taxation of Consumption ♦ Actual Deadweight Losses of Taxation

Most taxes change behaviour, distort economic activity and create a deadweight loss. This chapter describes how the main forms of taxation cause a deadweight loss and how this loss can be quantified. Following an introduction to the deadweight loss of taxation, we examine the deadweight losses due to income taxes on labour and capital and the losses associated with consumption taxes. The final section discusses the overall deadweight loss of a taxation system.

The Deadweight Loss of Taxation

A **deadweight loss** (DWL) is an economic loss for which there is no offsetting benefit. When associated with taxation, DWL is sometimes described as excess burden. In this chapter, we use the terms DWL and excess burden interchangeably but most often use the term DWL.

Deadweight loss
An economic loss with no offsetting benefit—sometimes called excess burden

An efficient tax imposes burdens on individuals by reducing their income, but it does not cause an excess burden associated with behaviour change. In other words, an efficient tax has income effects but no substitution effects. A head tax is an example of an efficient tax because it reduces an individual's income by a given amount independently of any action that he or she might take. Such a tax is a transfer payment from taxpayer to government. One person's tax is offset by government revenue gain. There is no DWL to the community.

To illustrate the concept of DWL, consider a tax on income. Suppose that Emma is willing to work 20 hours a week for a minimum annual payment of $20 000 and that, in line with the value of her marginal product, she receives $24 000. Emma has a surplus from work of $4000 a year. If Emma's income were taxed at a rate of 25 per cent, she would receive only $18 000. Because this after-tax income would not compensate for the loss of her household production and leisure, Emma changes her behaviour and does not take on paid employment. Accordingly, she would pay no tax. Nevertheless, the tax imposes a DWL on society. Emma has a net welfare loss of $4000. But there is no offsetting benefit to anyone else.

To quantify DWL, we draw on our discussion of welfare measurement in Chapter 6. Welfare measures may be based on the principle of compensating or equivalent variation (CV or EV). Adopting the CV principle, measures of welfare changes are based on the expenditure that would maintain the existing level of welfare (utility) in society *before* any change is made. The cost of a tax increase to someone is the minimum dollar amount that she would be willing to accept as compensation for the increase in tax and be no worse off than before. The benefit of a tax reduction is the maximum amount that she would be willing to pay for the reduction and be at least as well off as before.

With the EV principle, measures of welfare changes are based on the expenditure that would maintain the level of real income *after* taxes change. The cost of a tax increase to someone is the maximum amount that she would be willing to pay to prevent it, given their new after-tax income. The benefit of a tax reduction is the compensation that she requires to forgo the reduction in tax. The benchmark here is the individual's level of real income (or utility) after the proposed change.

These measures of welfare change reflect an individual's loss or gain, inclusive of income effects. When a tax is imposed, the loss to an individual is the sum of the loss of income (the burden) and the loss over and above the tax paid (the DWL or excess burden). The DWL is due to the substitution effect of a tax. To illustrate this with another example, consider a tax on beer which causes Charles to reduce his beer consumption from 12 to 10 bottles a week. The weekly burden to Charles is the extra cost of the 10 bottles of beer (the income effect) plus the loss of surplus from forgoing the extra two bottles (the substitution effect). However, the tax that Charles pays is income to government and will provide benefits or lower tax to Emma. There is no net cost arising with this transfer payment. On the other hand, the DWL (or excess burden) of the tax associated with the substitution effect has no offsetting benefit.

Substitution effects occur when quantities change, be they quantities of labour or consumption, in response to changes in relative prices (holding real income constant). However, changes in prices may not change quantities when substitution and income effects work in opposite directions. For example, a tax on labour encourages individuals to *substitute* from market goods purchased from labour income which is taxed to leisure and home production which are not taxed. The *income* effect arises because individual utility is a function of market goods and leisure and, as consumption of market goods falls, the demand for leisure falls and individuals work more. DWL is caused by the substitution effect and to measure this loss substitution and income effects must be separated.

Given that nearly all taxes create some DWL, an efficient tax system is the one that creates least total DWL. This tax system would equate the marginal DWL per dollar of tax raised across all revenue sources. Of course, such an efficient tax system would not be socially optimal. To determine social optimality, which depends on equity as well as efficiency, it would be necessary to compare and weight gains and losses to all individuals in society. This complex exercise is discussed in the next chapter.

In this chapter we discuss efficiency issues and examine the DWLs of various taxes without making interpersonal comparisons of utility. Tax *A* is more efficient than tax *B* if, for a given level of taxpayer welfare, it raises more tax revenue than tax *B*. Tax *A* is also more efficient than tax *B* if, for a given level of tax revenue, it leaves at least one taxpayer better off. In both cases, tax *A* would make either the taxpayer or the tax recipient better off without making the other worse off. Formally, it is Pareto efficient.

Taxation of Labour Income

A tax on labour income may affect many aspects of labour supply. These include participation in the workforce (entry or exit choices), choice of occupation, hours of work and work effort. Most literature (for example, the major Australian review by Dandie and Mercante, 2007) focuses on the effects of income tax on hours of work and we follow this practice here, but we also note some of the other effects of income tax on labour.

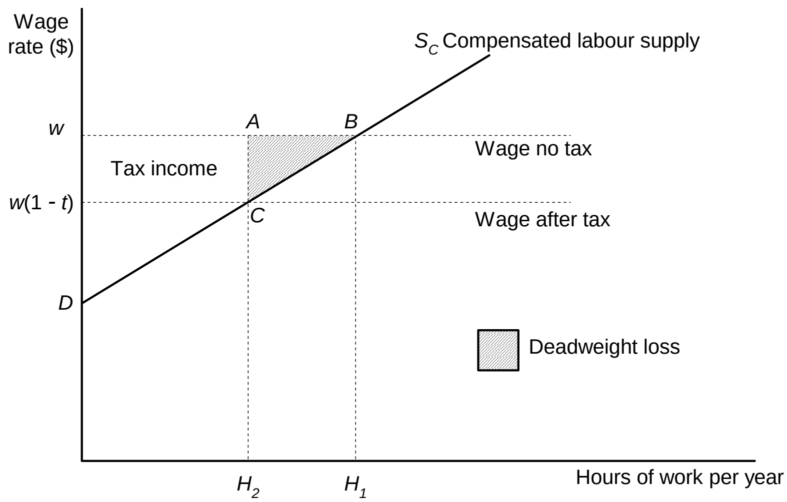

Figure 27.1 Deadweight loss of a tax on labour

The DWL of a tax on labour is shown in Figure 27.1. In a competitive market, the wage rate (w) for Emma is represented by a horizontal schedule; it does not vary with Emma's hours of work. Emma's supply curve is here a **compensated labour supply curve**. This shows the lowest wage for which Emma is willing to work for each extra hour, holding her utility from consumption of market goods and leisure constant. Thus, it shows the substitution effect on her labour supply of changes in the relative price of market goods and leisure, holding utility constant As the wage rate falls, Emma reduces her work. Without any tax, Emma enjoys total surplus equal to triangle wBD, which is the difference between her wage and the minimum amount that she requires as compensation for loss of leisure. Now if a tax is imposed on the wage at a rate (t), Emma receives an after-tax wage of $w(1– t)$ and reduces work hours from H_1 to H_2. She pays a tax equal to area $wACw(1– t)$. But she also loses surplus equal to triangle ABC. This is the DWL due to the tax-induced fall in the labour supply. It is the amount by which Emma's loss of welfare exceeds the transfer to government.

Compensated labour supply
A supply curve that shows how quantity of labour supplied varies with the wage rate, holding utility constant

Income and substitution effects

Unlike the compensated labour supply curve, the ordinary (uncompensated) labour supply curve includes income effects. A person's ordinary labour supply curve may be perfectly inelastic even though his or her compensated labour supply curve is upward sloping.[1] As Emma's net wage falls, the relative price of leisure falls and Emma substitutes leisure for market goods. But the income effect works the other way because the demand for leisure falls as Emma's income falls. Overall, a tax on labour income may have little or no effect on Emma's hours of work. However, there may still be a DWL due to the substitution effect.

Figure 27.2 overleaf illustrates the substitution and income effects. The line GL shows Emma's initial budget constraint with hours of leisure on the horizontal axis and consumption of market goods (or income) on the vertical axis. A tax on labour income rotates her budget line to G_2L. The tax reduces her potential consumption of goods, but it does not affect the total amount

1 An individual's labour supply curve may even be backward bending. As the wage falls an individual may work more hours if the income effect of the fall is greater than the substitution effect.

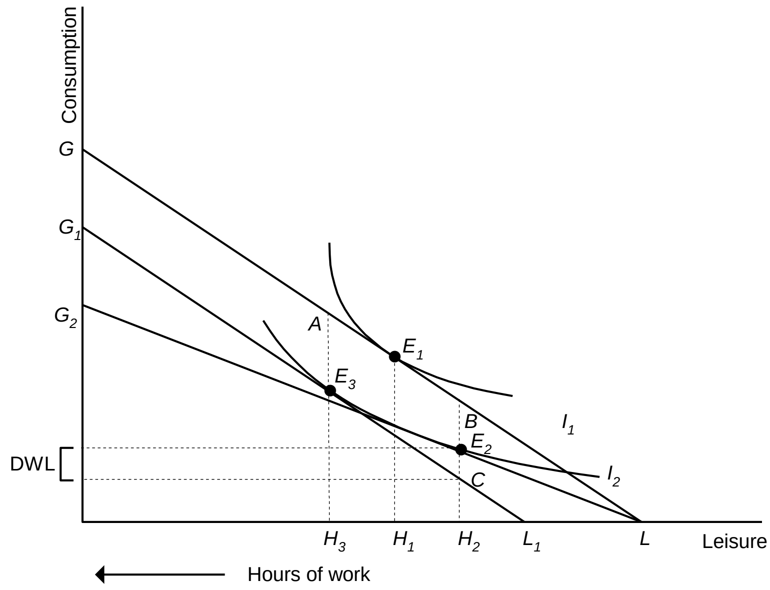

Figure 27.2 Tax on labour: income and substitution effects

leisure that she may enjoy. Initially Emma chooses position E_1 and works H_1 hours (note that hours of work are measured from point *L*). After a tax on labour income is introduced, Emma chooses E_2 and works H_2 hours, which is a slight fall in hours of work. Now the move from E_1 to E_2 can be decomposed into income and substitution effects

The income effect is measured by holding the relative price of leisure and other goods constant (thus excluding any substitution effects) and drawing a line parallel to the initial budget line (*GL*) that is tangent to the indifference curve I_2 at E_3.

The parallel line G_1L_1 represents the lump sum tax that would leave Emma on the same indifference curve as at E_2. Given a lump sum tax, Emma would choose the combination of goods and leisure shown by point E_3. The move from E_1 to E_3 represents the income effect. At this point, Emma works more hours (H_3) than at E_1. However, the tax on labour causes Emma to substitute leisure for work. The substitution effect is reflected in the move from E_3 to E_2. What then is the DWL of a tax on labour income compared with a lump sum tax? Emma enjoys the same level of utility at E_3 and E_2 even though she pays more tax at E_3. At E_3, she pays AE_3 tax. At E_2, she pays BE_2 tax. The revenue loss (E_2C) is the equivalent variation measure of the DWL of the tax on labour.

Individuals may also adjust to a tax on labour income by changing occupations. These changes may also generate a DWL. Suppose that Emma works in a stressful marketing job for a gross income of $60 000 a year but could work in publishing for $50 000 a year which she would enjoy more. Emma requires $6000 to compensate her for working in marketing compared with publishing. Before tax, she has a surplus of $4000 from working in marketing. However, suppose that, after tax, Emma would earn $40 000 from marketing and $35 000 from publishing (this implies a marginal tax rate of 50 per cent on income over $50 000). Emma now chooses to work in publishing. As a result, she pays $15 000 tax and bears an excess burden of $4000 (the loss of the surplus she obtained from her marketing job). Put another way, a lump sum tax of $15 000 would raise the same amount of revenue as the tax on labour, but Emma would stay in marketing and continue to enjoy a net benefit of $4000.

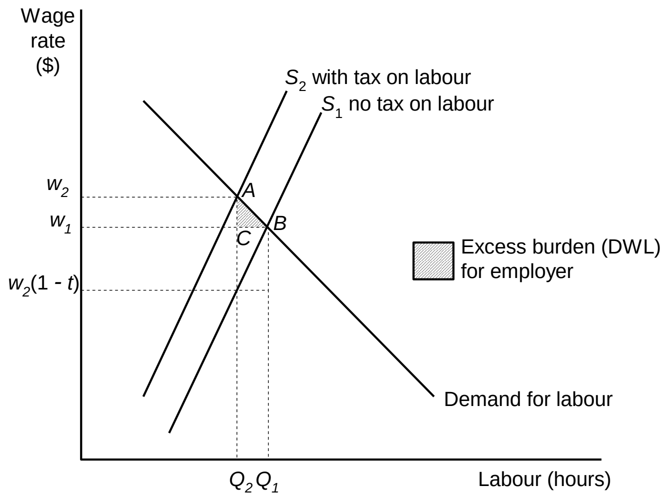

Figure 27.3 Tax on labour: excess burden on employers

So far, we have examined the excess burden on workers of a tax on labour. But as we saw in Chapter 26, a tax on labour may increase gross wages. Consequently, firms may also bear an excess burden. Figure 27.3 shows a market demand curve for labour along with an ordinary (uncompensated) supply curve for labour. A tax on labour shifts the supply curve upwards from S_1 to S_2. Total hours worked fall from Q_1 to Q_2. The gross wage rises from w_1 to w_2. The labour tax paid by firms is given by area w_2ACw_1. The excess burden borne by firms equals area ABC.

Quantifying deadweight loss

Assuming an elastic demand for labour and a linear compensated labour supply curve, as in Figure 27.1, the DWL of a tax on income from labour is given by:

$$DWL = 0.5\ (Q_1 - Q_2)\ (w_1 - w_2) \qquad (27.1)$$

where Q is the (compensated) quantity of labour supplied, w is the net wage received and subscripts 1 and 2 refer to the quantities and wages before and after-tax respectively. Thus to estimate DWL, we need to estimate the change in the net wage received and the compensated changes in quantity of labour supplied.

To understand the factors that determine the deadweight loss it is helpful to express Equation 27.1 in terms of the compensated elasticity of supply (η_{cs}) and the tax rate (t), which is the ratio of the tax (T) to the initial wage. Now the elasticity of compensated supply (η_{cs}) is:

$$\eta_{cs} = (\Delta Q/Q_1)/(\Delta w/w_1) \qquad (27.2)$$

So

$$\Delta Q = (\Delta w/w_1)\,\eta_s Q_1 \qquad (27.3)$$

Also

$$\Delta w = (w_1 - w_2) = T \qquad (27.4)$$

so

$$DWL = 0.5\ (\Delta w/w_1)\ Q_1\eta_{cs}T\ = 0.5\ Q_1 w_1 \eta_{cs} t^2 \qquad (27.5)$$

The DWL is the product of half the initial wage payments (Q_1w_1), the compensated elasticity of labour supply and the square of the tax rate.[2] If the payments base is initial wage

[2] If the demand curve for labour is not perfectly elastic, DWL includes a loss of employer surplus as in Figure 27.3. However, there is a smaller fall in labour employed. The total DWL is then equal to $0.5wQt^2/((1/\eta_d)+(1/\eta_{cs}))$ where η_d is the elasticity of demand for labour (Bishop, 1968). This expression equals Equation 27.5 when $\eta_d = \infty$.

payments as in Equation 27.5, the estimate is a compensating variation measure of welfare loss. If the base is post-tax wage payments, the estimate is an equivalent variation measure. In either case, the critical determinants of DWL are the labour supply elasticity and the tax rate. DWL rises proportionately with the elasticity of supply and with the square of the tax rate. The latter is an important result because it implies that broad-based low tax rates on a comprehensive tax base are more efficient than narrowly based high tax rates which collect a similar amount of tax revenue.

Average deadweight loss
Total deadweight loss divided by total tax revenue

Marginal deadweight loss
The change in deadweight loss with a marginal increase in a tax

To illustrate the DWL of a tax on labour income, suppose that Charles is willing to work 100 hours a month at $30 per hour, the tax rate is 40 per cent and Charles' ordinary labour supply elasticity is 0.25. Given these parameters, Charles will reduce his work hours by 10 per cent (work 90 hours) and pay $1080 in tax per month (90 hours × $30 × 0.4). Assume also that Charles' compensated supply elasticity is 0.5. Applying Equation 27.5, total DWL is $120. **Average DWL** is 11.1 cents per dollar of tax revenue. If the tax rate were 50 per cent, DWL would rise to $187. Although the tax rate rises by 25 per cent, the DWL rises by just over 50 per cent. Thus, the **marginal DWL** is much higher than average DWL.

Elasticity of labour supply. Apart from tax rates, the compensated labour supply elasticity is a major determinant of DWL of tax on labour income. The higher this elasticity, the higher the DWL. However, estimates of labour supply elasticities vary widely with the type of labour—with age, sex, household composition, part- or full-time work and occupational context. They may also vary because of differences in data sets and estimation methods.

Labour supply elasticities are estimated most often from cross-sectional individual workforce data. Hours of work of individuals are regressed against after-tax wage rates, non-labour income and a set of control variables such as education, marital status, number of children and so on. These other factors affecting labour supply must be accounted for in order to identify accurately the effect of income on labour supply.

Gruber (2016, Chapter 21, pp.663-4) describes two other methods of estimating labour supply elasticities—experimental evidence and quasi-experimental evidence. As an example of experimental evidence, he cites a randomised experiment in the United States in which government randomly assigned low income individuals to alternative benefit-tax schemes between 1968 and 1976. The schemes varied in the size of the grant provided to individuals and the rate at which the grant was withdrawn as income rose, which is an implicit tax rate. Analysts were able to estimate how labour hours responded to the implicit tax rates. The estimated overall elasticity of labour was quite low at only about 0.1.

As an example of quasi-experimental evidence, Gruber cites analysis of labour supply before and after the 1986 *Tax Reform Act* in the United States. In general, labour supply before and after a major tax change provides useful data for analysis of labour supply. However, it is important to identify and take account of concurrent changes and other characteristics of individuals that may affect the labour supply.

Another complication is the distinction between uncompensated and compensated labour supply. The latter includes only the substitution effect. In the cross-section regression approach described above, the change in labour supply with respect to non-labour income (the coefficient on non-labour income) reflects only the income effect. On the other hand, the coefficient on after-tax labour income includes income and substitution effects. Subtracting the former coefficient from the latter gives an estimated substitution effect. If the income effect is negative, which it often is, the ordinary labour supply elasticity is lower than the compensated supply elasticity. For example, if the estimated ordinary labour supply elasticity is 0.2 and this includes an income elasticity of labour supply of say –0.2, the compensated supply elasticity would be 0.4.

Table 27.1 Estimates of uncompensated labour supply elasticities with respect to wages

Population group	*Australian studies*		*Other countries*[a]		
	studies (no)	*Range*	*Median*	*Studies (no)*	*Range*
Married men	5	-0.19 to 0.26	0.00	3	-0.29 to 0.24
Married women	11	-0.19 to 1.3	0.18	12	-0.37 to 0.71
Single men	1	0.28	0.28	1	0.63
Single women	1	0.34	0.34	1	0.82
Lone parents	3	-0.15 to 1.48	0.20	5	0.11 to 1.44

(a) Canada, New Zealand and the United Kingdom.
Source: Dandie and Mercante (2007).

Traditionally empirical studies (e.g. Heckman, 1993; Blundell, 1996) found that the ordinary (uncompensated) labour supply elasticity with respect to the after-tax wage is only marginally positive at about 0.1 for the primary income earner (most often males) and varies from 0.5 to 1.0 for secondary income earners. After taking out income effects, compensated labour supply elasticities may be 0.2 to 0.3 points higher than uncompensated supply elasticities. However, the results vary with individual and labour supply circumstances.

Dandie and Mercante (2007) reviewed estimated uncompensated elasticities in several Australian and other studies from Canada, New Zealand and the United Kingdom. The results, summarised in Table 27.1, are consistent with traditional findings though it should be noted that the groupings (married men, married women etc.) are not necessarily synonymous with primary and secondary earners. Note also that uncompensated labour supply elasticities can be negative where the income effect is greater than the substitution effect, whereas compensated labour supply elasticities are highly unlikely to be negative.

In a more recent study, drawing on data from Sweden in the 1980s, Blomquist and Selin (2010) estimated that the compensated labour supply elasticities with respect to wage rates were about 0.15 for males and 0.50 for females, with uncompensated elasticities only some 5 percentage points higher. However, Blau and Kahn (2007) found that married women's labour supply elasticities fell by just over 50 per cent between 1980 and 2000, which reflected significant changes in opportunities and in preferences towards work, children and leisure.

Finally, recall that taxation can affect labour supply in many ways, for example workers may move to less taxed, lower paid, jobs or put in less work effort. A significant consequence is that the elasticity of tax revenue to tax changes is almost always higher than the elasticity of labour supply hours. Blomquist and Selin (2010) estimate that the elasticity of tax revenue to tax changes for men is about 0.20 and for women rises to about 1.0.

Differential taxation of labour income

We have assumed so far that all labour income is taxed in a similar way, although it may be taxed at different marginal rates. We now consider the effect of taxing different types of labour income at different rates.

The most extreme differential occurs with home labour which avoids any taxation. In Figure 27.4 overleaf, panel (a) shows work in the market and panel (b) work at home. The value of the marginal product of labour (VMP) falls as more hours are worked. In competitive markets with no tax, if individuals are indifferent to where they work, they allocate time to equate VMP_M and VMP_H, where subscripts M and H indicate market and home respectively. The real wage in both sectors would be w_1. If the VMPs are not equal, an individual can increase his or her real income by doing more work in the sector with the higher VMP.

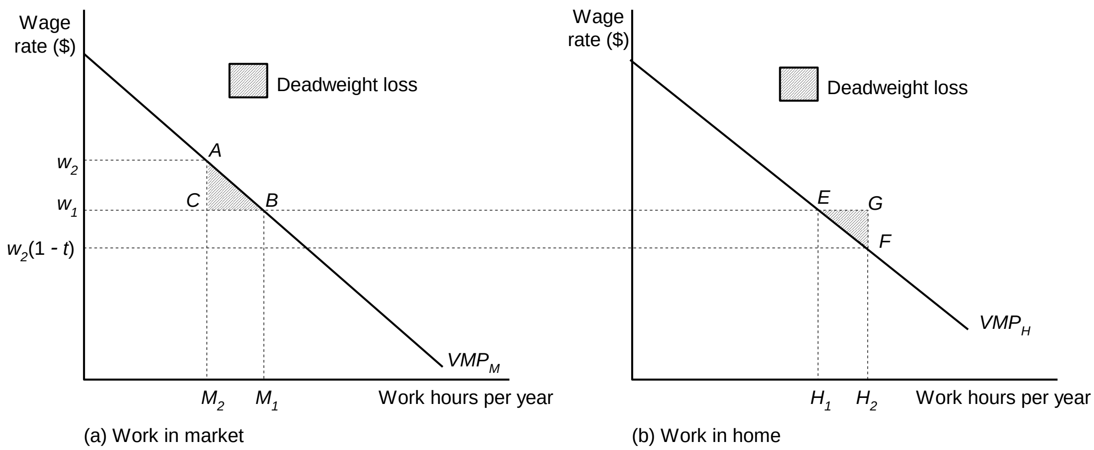

Figure 27.4 Deadweight loss of a differential tax on labour

If a tax is imposed on market income, the initial equilibrium no longer maximises take-home income. To maximise this income, individuals will reallocate time to the home sector. This shift causes a downward move along the VMP_H curve. A new equilibrium occurs when the after-tax return in the two sectors is equal, that is, when $VMP_H = VMP_M\ (1 - t)$ where t is the tax rate on market income.

Hours worked in the home increase from H_1 to H_2. If total working hours are fixed, hours worked in the market sector fall by an equal (offsetting) amount from M_1 to M_2. This is inefficient because the value of output lost in the market (area ABM_1M_2) is greater than the gain in output at home (area EFH_2H_1). The net loss in value of output is the DWL of the differential tax.[3] Equivalently, the DWL equals areas $ABC + DEF$. Boskin (1975) estimated that this loss equalled between 6 and 13 per cent of tax revenues in the United States. A similar method of analysis would apply to any differential taxation of labour income, for example a payroll tax on large firms and exemptions for small ones.

Taxation of Income from Capital

A comprehensive income tax taxes labour income that is saved and the returns from the savings (the capital). Like other taxes, a tax on income from capital has a substitution and an income effect. Such a tax increases the relative price of future consumption and so causes present consumption to be substituted for future consumption. On the other hand, because the tax reduces future consumption, individuals may save more to offset this loss. Thus savings may not fall because the income effect of a tax on savings may offset the substitution effect.[4] However, there would still be a DWL loss associated with the substitution effect.

To analyse the effect of a tax on income from capital, we examine how such a tax may affect consumption over time. Suppose Emma earns $50 000 in period 1 and expects to receive a pension of $20000 in period 2. And suppose that the real rate of interest is 5 per cent per period. If Emma saves, say $20000, she could consume $30 000 in the first period and $41 000 ($20000 + ($20 000 × 1.05)) in the second. Assuming Emma cannot borrow against her pension, her consumption choices before tax are illustrated by the *FF* line in Figure 22.5, where

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[3] This assumes that individuals are indifferent between working outside and inside the home.

[4] Suppose that $U = f(C_n, C_f)$ subject to $C_n + C_f/(1+r) = W_n + W_f/(1+r)$ where C is consumption, W is wages, n and f denote now and future, r is the discount rate. A tax on savings reduces total income and both C_n and C_f.

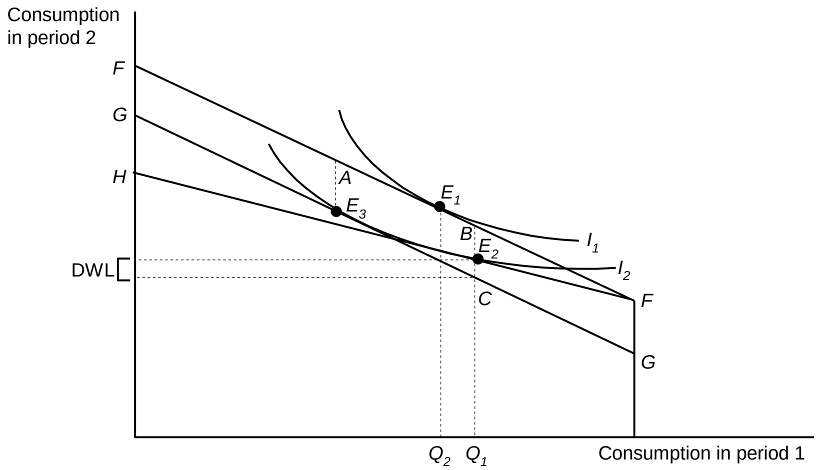

Figure 27.5 Excess burden of a tax on income from capital (savings)

consumption in periods 1 and 2 is shown on the horizontal and vertical axes respectively. By deferring part of her consumption, Emma can choose any point along this line. Emma must give up $(1 + r)$ units of marginal consumption in period two for an extra unit of consumption in period one.[5]

To maximise her utility, Emma trades present against future consumption. If a marginal unit of present consumption is valued at more than $(1 + r)$ future units, she would consume more in period 1. Emma maximises her utility when the marginal rate at which she is willing to substitute future for present consumption equals the rate at which she can exchange future consumption for present consumption, which is at point E_1. The convex indifference curves imply that, as Emma's consumption in either period falls, the marginal rate at which she is willing to substitute consumption in the other period rises. Now suppose that interest income is taxed. The budget constraint rotates to curve *FH* and Emma chooses position E_2 which sits on indifference curve I_2. In this example, Emma increases her consumption in period 1 but she reduces it in period 2.

To identify the welfare effects, income and substitution effects must be distinguished. As we have observed, a tax on future income reduces Emma's lifetime income and, with no change in relative prices, would generally reduce consumption in both periods. On the other hand, the tax makes future consumption more expensive relative to present consumption. Thus, Emma is likely to substitute present for future consumption.

To show the DWL, we draw a budget line *GG* parallel to the initial budget constraint and tangent to the new indifference curve I_2. With this budget constraint, Emma would choose point E_3. This represents the income effect with no substitution effect because the price of future consumption is unchanged. Now with a lump sum tax, Emma would pay AE_3 tax. On the other hand, with the tax on interest income, Emma pays BE_2 tax. Thus, for the *same* level of taxpayer welfare after the tax is imposed, a lump sum tax would raise additional tax revenue E_2C. This is an equivalent variation measure of the DWL of the tax.

Some complications may be observed. First, most taxes on interest income are levied on nominal rather than real income. This results in high real marginal tax on income.[6] Second, income from different forms of capital is often taxed at different rates. A high tax rate on one

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[5] The method of analysis for taxation of income from capital is similar to the analysis of taxation of income from labour. The difference is that in this case consumption in period 2 is taxed instead of labour.

[6] Suppose that the nominal rate of interest is 10 per cent, the tax rate is 40 per cent and the inflation rate is 5 per cent. The real return on $100 = $(100 + 10 × 0.6) / 1.05 = $100.95 - $100 = $0.95. The real return after tax is less than 20 per cent of the real return without tax.

form of capital may divert savings into another form of capital with a lower gross return. Because this is a less productive investment, there is a DWL associated with this switch in investment.

Finally, not all the burden of the tax on income from capital is borne by savers. If this tax reduces savings and causes interest rates to rise, firms would pay more for capital. There is a DWL for firms who now employ less capital. The analysis of this loss is similar to that for firms that employ less labour because a tax on labour has increased wages (see Figure 27.3). The size of the DWL depends on tax rates and the elasticities of demand for and supply of capital for business.

The impact on savings of a tax on income from capital can be estimated by time series regression analysis in which quantity of aggregate savings is explained by the expected real after-tax rate of return to savings, disposable income and other relevant factors. A positive relationship between aggregate savings and the after-tax rate of return variable implies that a tax on income from capital would reduce savings. However, there are various problems with this kind of analysis. One is that estimates of expected real after-tax returns on savings require estimates of expected rates of inflation. A second is the variety of after-tax rates of return available in different investment vehicles. In addition, the regression analysis may not distinguish between income and substitution effects.

Such difficulties may explain the variety of estimates of the elasticity of savings with respect to the after-tax interest rate. In an early study of the responsiveness of savings to interest rates, Boskin (1978) estimated that the interest elasticity of savings was in the range of 0.2–0.4. Attanasio *et al*. (1995) reported an estimated elasticity of 0.67. Auerbach and Slemrod (1997) surveyed the literature and concluded that the overall elasticity of savings to interest rates is very low or zero because the income and substitution effects cancel out. This would imply that a tax on savings would have negligible impact on borrowing costs and investment. Hence there would be no deadweight loss from reduced investment by firms.

Nevertheless, from a saver's perspective changes in after-tax interest income have contrary income and substitution effects. A low total elasticity of savings with respect to the after-tax interest rate could be consistent with a pure substitution effect in the order of 0.3–0.4. This could result in a significant deadweight loss.

Selective Commodity Taxes

We now consider the DWL associated with selective commodity taxes. Figure 22.6a shows an ordinary (uncompensated) market demand curve for a commodity and two supply curves (S_1 and S_2). A unit tax (*AC*) shifts the supply curve from S_1 to S_2. The price to consumers rises from P_1 to P_C, while producers now receive P_S (the after-tax price). Consumption falls from Q_1 to Q_2. The tax paid (rectangle P_CACP_S) is a transfer from taxpayers to tax recipients. However, the losses of consumer surplus (*AEB*) and producer surplus (*BEC*) are a deadweight loss because there is no offsetting benefit.

To be exact about the DWL, we should distinguish between the income and substitution components of the demand curve for a commodity. Panel (b) of Figure 27.6 has the same elements as panel (a) but includes the compensated demand curve. For a price increase (fall) the compensated demand lies above (below) the ordinary demand curve. If a commodity tax increases the consumer price from P_1 to P_C, the effect on consumption can now be broken into substitution and income effects. Holding real income constant, the substitution (relative price) effect causes consumption to fall from Q_1 to Q_S. The income effect causes consumption

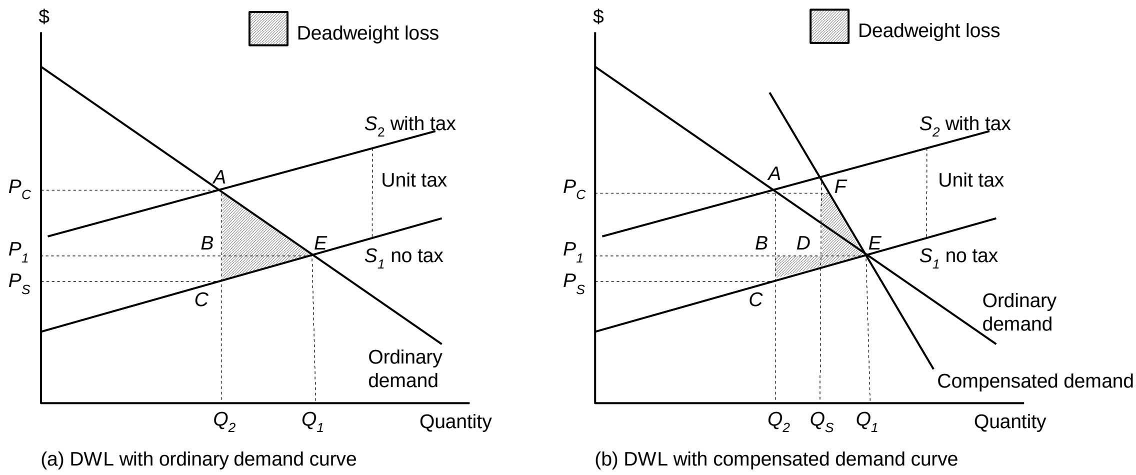


Figure 27.6 Deadweight loss of a selective commodity tax

to fall from Q_S to Q_2. The compensating variation measure of the DWL for consumers equals triangle *FED* instead of *AEB*. The loss of producer surplus remains area *BEC*.

However, as we saw in Chapter 6, for small price changes there is little income effect and differences between the uncompensated consumer surplus measure of DWL and the compensating (or equivalent) variation measure of loss are small.

Estimating deadweight loss using indifference curves

The concept of DWL can be illustrated using indifference curves and budget constraints. The DWL is the difference between the consumer's burden with a lump sum tax (the income effect) and the burden with a commodity tax (which includes the substitution effect as well as the income effect). The equivalent variation can be estimated in two ways. Holding after-tax utility constant, we can estimate the extra revenue that a lump sum tax would raise compared with a commodity tax. Alternatively, with tax revenue constant, we can estimate the extra expenditure required to make an individual as well off with a commodity tax as with a lump sum tax.

We consider the former approach first. Figure 27.7a overleaf shows Emma's initial budget constraint as line *GF*. Emma can spend her income on food or on other goods. The indifference curve I_1 shows the maximum utility that Emma can obtain given her budget constraint and she chooses position E_1. Now suppose that government levies a lump sum tax on Emma and her budget line shifts to G_1F_1. This is parallel to *GF* as the relative price of food and other goods has not changed. Emma now selects the E_2 combination of goods, which maximises her utility given her new budget constraint. The vertical distance between the budget constraints (AE_2) measures the tax revenue collected.

Now consider what happens if government taxes food. Emma's budget line rotates from *GF* to GF_2. Because the price of food has increased relative to other goods, the new budget curve is steeper than *GF*. Holding Emma's utility constant (along the I_2 indifference curve), Emma chooses the E_3 combination of goods. The substitution effect induces Emma to reduce her food consumption from Q_2 with the lump sum tax to Q_3. Now tax revenue equals BE_3. Holding Emma's welfare constant along I_2, there is a loss of tax revenue equal to $AE_2 - BE_3$, which is equal to *NM* on the vertical axis. *NM* is a measure of the DWL of the tax on food.

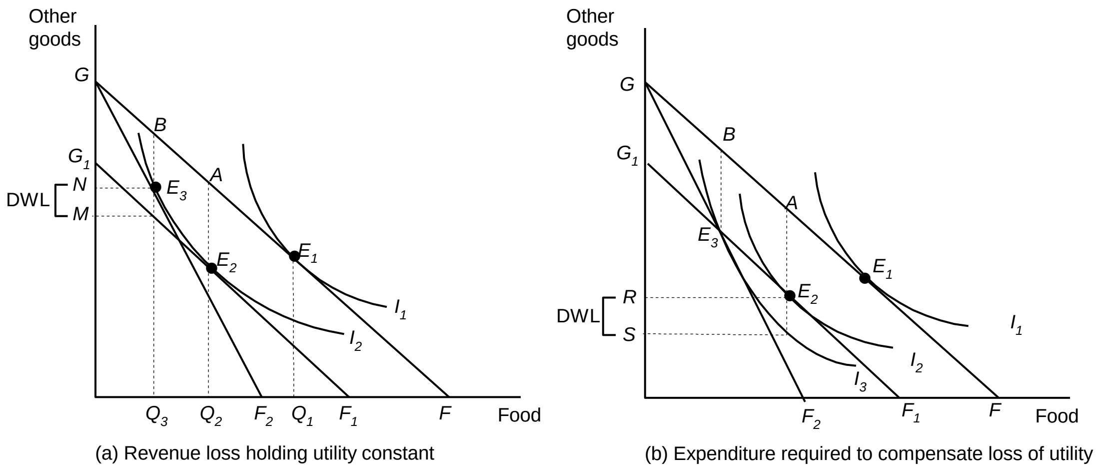


Figure 27.7 Estimating the deadweight loss of a commodity tax for an individual

Given that AE_2 is a lump sum tax, the fall in tax revenue occurs because Emma substitutes other goods for food.

Panel (b) of Figure 27.7 shows what happens when government has a revenue target AE_2. To reach the revenue target with a commodity tax, government would have to increase the tax on food. The GF_2 curve would be steeper than in panel (a). Holding tax revenue constant, Emma would be on indifference curve I_3 instead of I_2. At her new equilibrium point E_3, Emma pays the same amount of tax with a commodity tax as with a lump sum tax, but she has less utility. Holding revenue constant, the vertical difference between the utility curves I_2 and I_3 is a measure of the deadweight loss. An expenditure of *RS* on other goods would be required to compensate Emma for the loss of welfare.

Quantifying deadweight loss

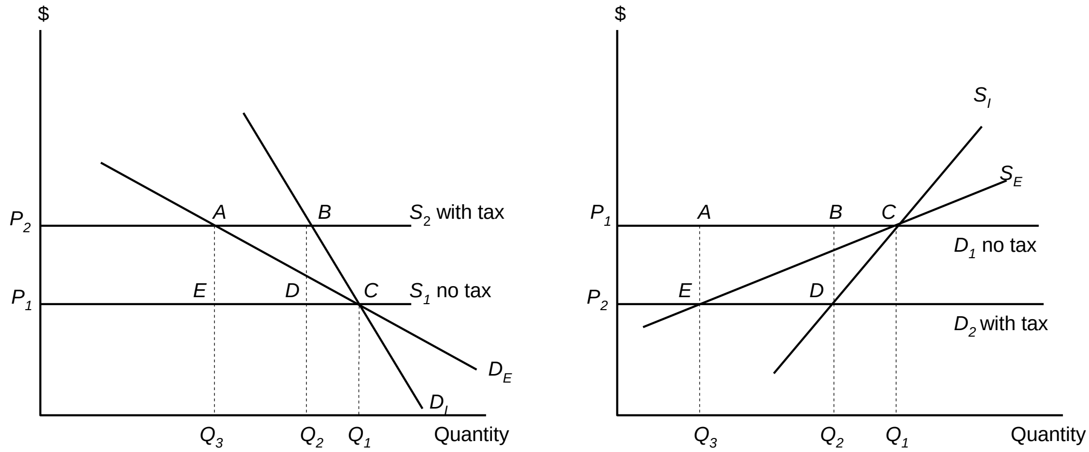
Following our previous analyses, DWL rises with the elasticities of the compensated demand and supply curves. This is illustrated with two polar examples in Figure 27.8. Panel (a) shows a perfectly elastic supply curve and two compensated demand curves, representing elastic demand (D_E) and inelastic demand (D_I). Assume that a commodity tax shifts the supply curve from S_1 to S_2 and that the consumer price rises from P_1 to P_2. The DWL with D_I equals area *BCD*. With more elastic demand D_E, DWL increases to area *ACE*.

Panel (b) shows a perfectly elastic demand curve and two supply curves, an elastic curve (S_E) and an inelastic one (S_I). Assume that a commodity tax shifts the demand curve down from D_1 to D_2 and that the price to suppliers falls from P_1 to P_2. The DWL with S_I is given by area *BCD*. With more elastic supply S_E, DWL increases to area *ACE*. The loss rises with the elasticities of demand and supply because these elasticities drive the changes in quantity demanded or supplied in response to changes in price.

Evidently, if the compensated demand schedule for a commodity is linear and supply is perfectly elastic, the deadweight loss is given by:

$$DWL = 0.5\,(Q_1 - Q_2)\,(P_2 - P_1) = 0.5\,\Delta Q\,\Delta P \qquad (27.6)$$

where *Q* and *P* are the quantity and consumer price respectively, subscripts 1 and 2 refer to quantities and prices before and after tax respectively and Δ represents the change in quantity or price. To quantify the loss, estimates of the changes in price and quantity as a result of the tax rate are required.



(a) DWL with elastic and inelastic demand (b) DWL with elastic and inelastic supply

Figure 27.8 Deadweight loss and demand and supply elasticities

To understand the factors that drive DWL it is helpful to express Equation 27.6 in terms of the compensated elasticity of demand (η_{cd}) and the tax rate ($t = T/P_1$) where T is a unit tax. Following the procedure that allowed us to derive Equation 27.5 from Equation 27.1, the loss in this case can be estimated as:

$$DWL = 0.5\ (\Delta P/P_1)\ Q_1 \eta_{cd} T\ = 0.5\ Q_1 P_1 \eta_{cd} t^2 \qquad (27.7)$$

where η_{cd} is the compensated elasticity of demand. Equation 22.7 indicates that DWL rises directly with the elasticity of demand and the square of the tax rate.[7]

Holding other factors constant, doubling a commodity tax results in a quadrupling of DWL. Suppose that a tax of \$1 per unit is imposed on a market in which 100 units are sold for \$10 per unit and that the price elasticity of demand is –1.0. The DWL would be approximately \$5 (equal to $\frac{1}{2}\Delta Q \Delta P = \frac{1}{2} \times 10 \times 1$). If a tax of \$2 per unit is imposed, DWL would be \$20 (equal to $\frac{1}{2} \times 20 \times 2$).[8]

This finding has significant implications. First, if compensated demand elasticities across commodities are similar, DWL is minimised by setting low tax rates across a broad range of goods rather than high tax rates across a narrow range of goods. If two commodities have similar compensated demand elasticities, to raise a given amount of revenue the DWL from taxation is minimised by an equal rate of tax on both commodities. The DWL with a tax of 10 per cent on both commodities will be one-half the loss with a 20 per cent tax on one commodity and no tax on the other. Second, the marginal DWL from raising an extra dollar of revenue exceeds the average DWL of taxation. The marginal loss is the policy relevant cost of raising taxes for public projects.

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7 When the supply curve is not perfectly elastic the excess burden also contains a loss of producer surplus. The deadweight loss is then equal to $0.5PQt^2/((1/\eta_d) + (1/\eta_s))$ where η_s is the elasticity of supply (Bishop, 1968). This expression equals Equation 22.7 when $\eta_s = \infty$.

8 This is an approximation. If a demand curve has a constant elasticity of –1 all along the curve, the demand curve would be a (non-linear) rectangular hyperbola.

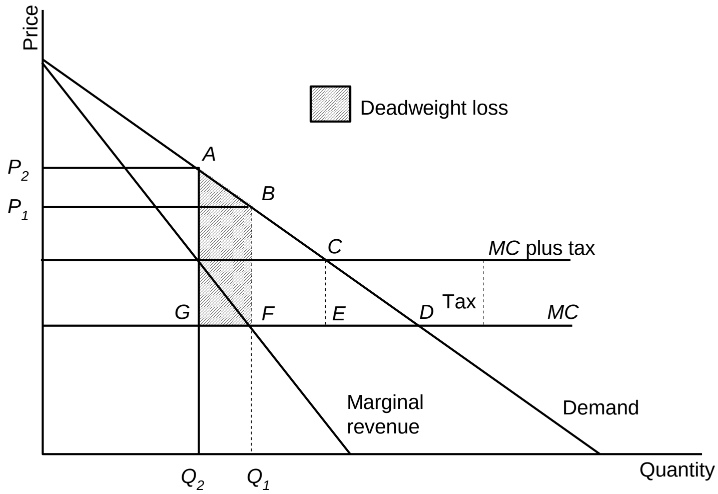


Figure 27.9 Deadweight loss of a tax on a monopoly

Other efficiency effects of selective commodity taxes

So far, we have assumed implicitly that government levies a partial consumption tax in a competitive market with no externalities and with no impacts on other markets. These assumptions are now relaxed.

A commodity tax with a monopoly. Figure 27.9 shows linear demand and marginal revenue curves in a monopoly market along with a constant marginal cost curve. For ease of illustration the ordinary demand curve is assumed to be similar to the compensated demand curve. A commodity tax *CE* is now imposed. If the market were competitive the DWL would equal area *CDE*. However, because a profit-maximising monopolist would equate marginal revenue to marginal cost, the tax would raise the price from P_1 to P_2 and consumption would fall from Q_1 to Q_2. The loss would be the much larger area *ABFG*, which is the difference between the price that consumers would be willing to pay for the commodity and the marginal cost of supply. Because price exceeds marginal cost in a monopoly market, a commodity tax has a greater DWL in this market than in a competitive market.

A tax on a commodity that causes a negative externality. As we saw in Chapter 13, a tax that reflects the marginal damage costs of a negative externality is called a corrective tax because it can correct the externality and produce a net benefit. Consider fuel consumption, which causes air pollution. Figure 27.10 shows the marginal private and social cost schedules (*MPC* and *MSC* respectively). The latter includes the cost of air pollution. With no tax on petrol, fuel consumption is Q_1, compared with the efficient quantity Q_2. The net social cost equals triangle *ABC*. If a corrective tax equal to *AC* is levied, the price rises to P_2 and consumption falls to Q_2. The corrective tax eliminates the *ABC* deadweight loss.

A tax on an untaxed substitute for a taxed commodity. This may also reduce the effect of an existing distortion. Suppose that initially beer is taxed but wine is not. A tax on wine may reduce the distortionary impact of the tax on beer. Figure 27.11 shows the initial compensated demand and supply for beer (D_1 and S_1). A tax on beer shifts supply to S_2, reduces output from Q_1 to Q_2, and causes a DWL of area *ACE*. After a tax is imposed on wine, the demand for beer rises from D_1 to D_2 and the quantity consumed increases from Q_2 to Q_3. The deadweight loss has fallen to

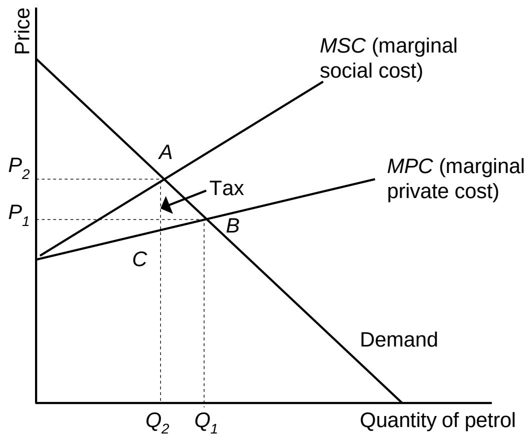


Figure 27.10 Benefit of a corrective tax

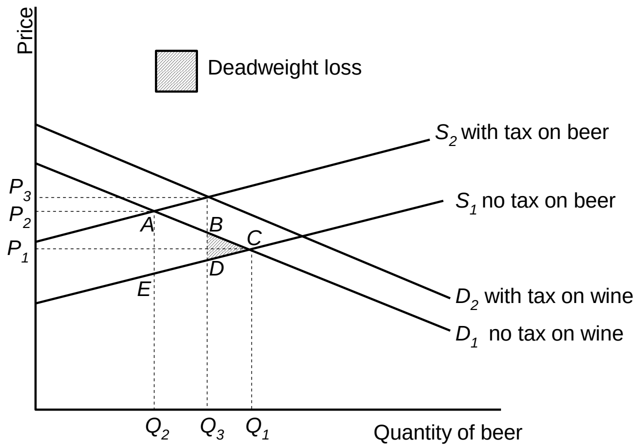


Figure 27.11 Deadweight loss in a second-best world

area *BCD*. As it happens, in this example consumption is still below the efficient level of Q_1. But the tax on wine has reduced the DWL of the initial tax on beer. This reduction in DWL from taxation of beer may partly or even fully offset the DWL associated with the introduction of a tax on wine.

General Taxation of Consumption

A general tax on consumption can take several forms. It can be a general expenditure tax (i.e. a tax on income less savings), a general tax on retail sales or a general value-added tax that excludes capital expenditures. Being equivalent taxes on a similar tax base, the tax rate would be the same in each case. Likewise, the DWL of each kind of general consumption tax would be similar unless there were some fiscal illusions. We also saw in the last chapter that a general tax on consumption is equivalent to a tax on labour. We would expect it therefore to have similar impacts—it would affect the supply of labour but not the supply of savings.

Consider first the impact of a general consumption tax on labour supply. Suppose that Emma earns \$20 an hour, or \$40 000 a year if she works full time, and that the average income tax rate is 25 per cent. The tax would raise \$10 000 revenue. Replacing the income tax with a general consumption tax, to raise equivalent tax revenue, government could levy a 33 per cent tax on consumption expenditure (\$30 000 × 0.33 = \$10 000). In both cases Emma would receive \$15 of goods in return for an hour's work. For a given tax revenue the after-tax rate of substitution between work and leisure is the same with a consumption (expenditure) tax as with an income tax. In both cases, Emma has to decide whether to forgo an hour of leisure for \$15 worth of goods.

It follows that, for any given tax revenue, a general expenditure tax has the same effect on labour supply as a tax on labour income. This assumes no fiscal illusion—that is, Emma understands the real (after-tax) purchasing power of an hour's work. If people perceive a tax on income to be a greater burden, it could be a greater deterrent to work than an equivalent tax on expenditure.

Now consider the effect of a general consumption tax on savings. Ignoring inheritances and bequests, suppose that Emma has only her own income and spends all of it in her lifetime. And suppose that Emma earns W_1 in year 1 and W_2 in year 2. In scenario A, she consumes all income when it is earned. In scenario B, she saves S_1 in year 1 and consumes these savings plus interest in year 2. With a tax on consumption the present value (PV) of Emma's consumption is the same in the two scenarios (C_A and C_B) despite the different consumption patterns.

Allow that consumption is taxed when it occurs at rate (t). Then,

$$PV(C_A) = W_1(1-t) + \frac{W_2(1-t)}{(1+r)} \tag{27.8}$$

$$PV(C_B) = (W_1 - S_1)(1-t) + \frac{W_2(1-t)}{(1+r)} + \frac{S_1(1+r)(1-t)}{(1+r)} \tag{27.9}$$

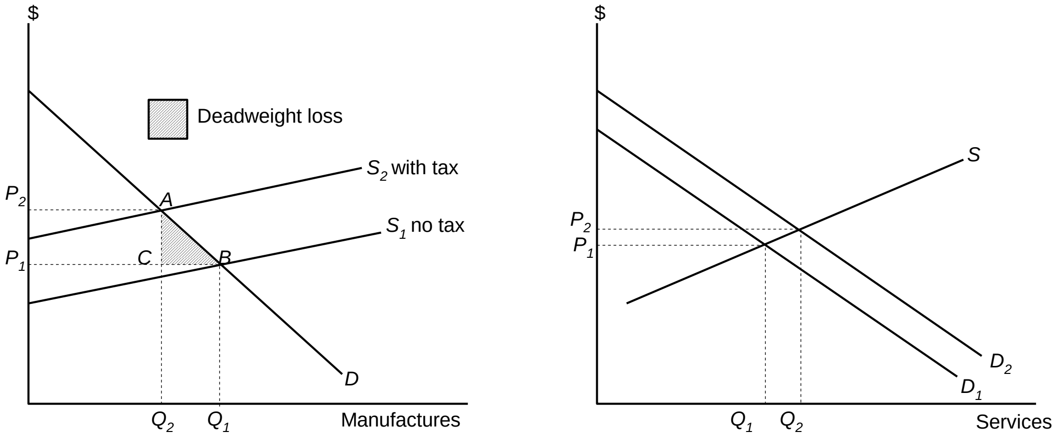
where r is the rate of interest. The present value of consumption is the same in Equations 27.8 and 27.9. Likewise, the present value of the tax paid is independent of the expenditure pattern.

With a consumption tax, savings are taxed only once—when they are spent. Thus, a tax on consumption, like a tax on wages, does not distort an individual's pattern of consumption (and savings) over time.

Incomplete general consumption taxes. Few general consumption taxes are comprehensive. In the European Union many goods are exempt from VAT. In Australia, the GST covers 57 per cent of expenditures. This differential tax treatment distorts the pattern of consumption.

Suppose that an economy consists of two goods, manufactures and services, and that manufactures are taxed whereas services are not. Panel (a) in Figure 27.12 shows the market for manufactures. The tax on manufactures shifts the supply curve for manufactures from S_1 to S_2. There is a DWL of triangle ABC, similar to that for a selective tax on one commodity. Panel (b) shows that the tax on manufactures raises the demand for services from D_1 to D_2. The quantity and price of services rises. However, there is no additional DWL in the market for services. The increase in the price of services is a transfer payment from consumers to producers. The full cost imposed on consumers who shift from manufactures to services is reflected in triangle ABC in panel (a).

Estimates of the DWL of consumption taxes are more complex when many different tax rates on commodities exist. It might be expected that a tax system with several commodity tax rates would distort consumption patterns more and cause a higher aggregate DWL than would a uniform tax on consumption. However, as we show in Chapter 28, an efficient commodity tax system may include differential tax rates that allow for differences in demand elasticities.



(a) Taxed sector: manufactures (b) Untaxed sector: services

Figure 27.12 Deadweight loss with an incomplete general consumption tax

Moreover, the DWL of a commodity tax on one or a few goods cannot be considered in isolation from other commodity taxes. The overall deadweight loss due to the tax system is not necessarily the sum of the individual distortions.

It may be reasonable to assess the impact of a particular tax holding constant impacts in other markets. However, to estimate the overall distortion of a consumption tax system the net impacts in all markets need to be considered simultaneously.

Actual Deadweight Losses of Taxation

Several studies have attempted to estimate total, average and marginal DWLs of major tax forms and indeed a total DWL for all taxes across an economy. For example, for Australia, Campbell and Bond (1997) estimated that the marginal DWL of an extra dollar of income tax revenue on labour incomes was between 19 and 24 cents in the dollar. Freebairn (1998) concluded that the DWL of the income tax on labour supply was about 2–3 per cent of GDP and that the total DWL of taxes on savings and investment could be 1–2 per cent of GDP. In the United States, Aaron and Gale (1996) estimated that the efficiency gains of replacing the hybrid tax system with a comprehensive income or expenditure system would be equivalent to between 2 and 5 per cent of GDP.

Table 27.2 overleaf presents detailed estimates of average and marginal DWLs for Australia taxes, prepared by KPMG Econtech (2010) using a computable general equilibrium (CGE) model for the Henry Tax Review (2010). The main findings are:

- Several taxes have a marginal DWL of less than 10 per cent, including the petroleum resource rent tax, taxes on land and the GST.
- The estimated marginal DWL of personal income tax is 23 per cent, of corporate income tax is 40 per cent and of payroll tax is 41 per cent.
- The marginal DWL of royalty taxes and taxes on insurance and gambling is over 60 per cent.

Key determinants of the estimated DWLs are the mobility and narrowness of the tax base. When a tax base is mobile, the taxed item can move. When a tax base is narrow, users of the taxed item can substitute untaxed substitutes. Thus DWL rises with mobility and narrowness.

Table 27.2 Estimated deadweight losses of Australian taxes (cents per $ of revenue)

Tax	*Marginal DWL*[a]	*Average DWL*
Tobacco excise (allowing for externalities)	-8	-23
Petroleum resource rent tax	0	0
Municipal rates	2	1
GST	8	6
Land taxes	8	6
Alcohol excise and WET	9	7
Fuel taxes	15	10
Stamp duties exc. real property	18	18
Luxury car tax	20	9
Labour income tax	24	16
Conveyancing stamp duties	34	31
Motor vehicle registration	37	32
Motor vehicle stamp duties	38	38
Corporate income tax	40	23
Payroll tax	41	22
Insurance taxes	67	47
Royalties and crude oil excise	70	50
Gambling taxes	92	54

(a) Actually for 5 per cent increases in each tax, so the estimates are not strictly marginal DWLs.

Source: KPMG Econtech (2010).

In interpreting these results, some caveats are necessary. First, as KPMG Econtech details, numerous assumptions underlie these estimates, including estimates of critical demand and supply elasticities. The zero estimate for the petroleum resource rent tax assumes only excess profits are taxed. The DWL estimates for land tax are underestimated because the modelling did not account for all the variations in these taxes. Other simplified assumptions about actual tax structures were unavoidably adopted. The results of such economic modelling depend on these input assumptions.

Second, the aggregate DWL of the tax system cannot be calculated simply by adding up the separate DWLs of all taxes. One tax or set of taxes may offset the effects of another tax. A CGE model of the economy is required that can compare the economy-wide output and DWLs under alternative tax systems. Such a model should include prices and demand and supply functions for each major sector as well as measures of income and output. KPMG (2010) does not provide an estimate of the DWL of all taxes. Using a CGE model, Diewart and Lawrence (1994) estimated that the DWL of taxation in New Zealand amounted to 5.5 per cent of GDP. Freebairn (1998) concluded, without using a CGE model, that the total DWL of taxation in Australia could be as high as 6 per cent of GDP and that compliance costs could be an additional 4 per cent of GDP.

Finally, estimates of the DWL of a taxation system relative to a costless lump sum system of taxation are of limited value. As we have observed, an individualised lump sum system of taxation based on individual capabilities is not feasible. A general (non-individualised) system of lump sum taxes does not satisfy the fundamental equity principle that tax should be paid in accordance with ability to pay. In practice, all tax systems are based on, and distort, the activity of firms or individuals. Thus, all tax systems have some DWL. To be policy relevant, the estimated cost of a tax system should be compared with the lowest DWL of a *feasible* tax system alternative. The evidence presented above suggests that the gains from an improved tax system in Australia could be substantial, but they are lower than the total DWL of the tax system.

Summary

- Most taxes change behaviour and cause resources to be reallocated. Unless a tax corrects for market failure, it results in an inefficient use of resources. This inefficiency is described as a deadweight loss or excess burden.
- Taxation of labour income influences workforce participation, supply of labour hours, choice of occupation and work effort. All such changes have deadweight losses.
- Most attention has been paid to the impact of taxation on labour hours. The deadweight loss rises with the compensated supply elasticity. This is typically quite low for primary earners but can be around 1.0 for secondary earners.
- Taxation of capital income encourages individuals to substitute present for future consumption, which has a deadweight loss. However, savings may not fall if the income effect of lower after-tax returns on capital encourages people to compensate by increasing savings.
- A tax on a commodity causes a deadweight loss when a consumer substitutes other goods for the taxed good. The loss rises with the elasticities of demand and supply and with the square of the tax rate.
- A general tax on consumption effectively taxes labour income and discourages market output. However, a general tax on consumption is rare.
- Most so-called general consumption taxes are selective taxes and have a deadweight loss as consumers substitute non-taxed or lightly taxed goods for more heavily taxed goods.
- The deadweight losses of Australian taxes vary greatly from around zero to over 50 per cent. Overall, the taxation of income and consumption in Australia may have an aggregate deadweight loss in the order of 5–6 per cent of GDP.
- The potential gains from an improved tax system are therefore substantial. However, it will never be possible to achieve a tax system free of any deadweight loss.

Questions

1. Explain the difference between the income and substitution effects of commodity taxation. Why is the deadweight loss of taxation associated only with the substitution effect?
2. What factors determine the size of the deadweight loss of taxation? Why does the marginal deadweight loss from raising one more dollar of tax revenue exceed the average deadweight loss?
3. What are the practical implications of your answers to (2) for determining income and consumption taxes?
4. (From Rosen and Gayer.) In the formula for deadweight loss given in Equation 22.5, the tax rate is less than one. Thus squaring the tax rate reduces the deadweight loss. Using t^2 in the formula rather than t makes the tax rate less important. Discuss.
5. What efficiency implications arise from the non-taxation of goods produced outside of the market?
6. Suppose that Craig is willing to work 40 hours a week at $40 per hour. Craig faces a tax rate of 40 per cent. His ordinary supply elasticity for marginal work hours is 0.5 and his compensated supply elasticity for marginal work hours is 0.7. Determine:
   i. The hours Craig will work given the tax rate and the amount of tax Craig will pay.
   ii. The deadweight loss of each dollar of marginal tax collected.
7. Suppose that a good is fixed in supply at $Q^S = 12$, and that demand for the good is given by $Q^D = 50 - 6P$. The government imposes a tax of $2 per unit on the consumer. Determine:
   i. The pre-tax price paid by consumers and the amount received by producers.
   ii. The post-tax price paid by consumers and the amount received by producers, and the share of the tax burden borne by producers and consumers.
   iii. The amount of government revenue raised by the tax.
   iv. The deadweight loss of the tax.
8. The government imposes a tax of $2 per unit on a commodity *Z*. The supply of *Z* is perfectly elastic, and the compensated price elasticity of demand is –0.2. Currently 100 units of *Z* are sold at a price of $4 per unit. Determine the deadweight loss that would arise as a result of the tax on *Z*.
9. Suppose that the community demand for beer is given by $Q^D = 50 - 2P$, where Q is thousands of litres of beer consumed each week. The supply for

beer is given by $Q^S = -50 + 10P$. The government imposes an excise tax of $1.0 per litre of beer consumed payable by beer retailers (approximately the current Australian rate on small barrels of beer). Determine:

i. The pre-tax and post-tax equilibrium price and quantity of beer.
ii. The tax burden borne by the sellers and consumers.
iii. The excess burden of the tax on the consumption of beer.

10. Suppose that, as a population policy, government taxes families for each child in excess of two in the family. Consequently, no family has more than two children and government collects no revenue from the policy. Does this mean that the policy has no deadweight cost?
11. Does a tax on income from capital create a deadweight loss when there is no change in the amount of saving?
12. It is often commented that the 'whole is not always equal to the sum of its parts'. What implication does this statement have for analysing the total deadweight loss of (i) commodity taxation and (ii) all taxes?
13. Can subsidies, such a subsidy on private health care insurance, be regarded as negative taxes and therefore be expected to have similar deadweight losses to positive taxes?
14. Government is considering raising taxes by 10 per cent on alcohol consumption, all food, mobile phones, laptop devices, land values and high income earners. Which of these taxes is likely to have the highest or least deadweight loss and why?

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