4. Optimal commodity taxation

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INTRODUCTION

Revenues from general consumption taxes, % of total tax revenue

Country	1965	1985	2000	2009
Australia	7.4	7.9	12.0	14.3
Austria	18.7	21.0	18.8	19.0
France	23.3	20.0	17.1	16.8
Germany	16.5	15.8	18.4	20.1
Ireland	**5.7**	**20.6**	22.1	23.0
Italy	12.9	14.5	15.4	13.1
Japan	0.0	0.0	9.1	**9.6**
Netherlands	12.4	16.2	17.4	18.3
Spain	22.2	14.7	17.5	13.0
Sweden	10.4	14.0	17.0	21.0
Switzerland	10.6	10.7	13.1	12.3
U. Kingdom	**5.9**	**15.9**	18.1	16.6
United States	4.8	7.9	7.6	**8.4**
Average	**11.9**	**15.8**	**19.7**	**20.0**

Source: OECD Revenue Statistics 1965-2013.

Commodity taxation in the OECD

As the preceding table shows:

1. Taxes on general consumption have become more important over time in the OECD average.

2. Adoption of the VAT has typically resulted in an increased fiscal importance of commodity taxes. In some cases this has occurred together with accession to the EU. This is very visible, for example, in the case of the UK and Ireland, which have become EU members in 1973.

3. Countries outside the European Union often place less emphasis on general consumption taxes (U.S., Japan). This is true even for countries that have adopted the VAT (like Switzerland, in 1995).

4. Commodity taxes are even more important for the budget of many developing and transitional countries, because they are relatively easy to collect, in comparison to income taxes. For example, in Chile (not covered in Table 3.1) revenues from general consumption taxes made up 42.5% of total tax revenue in 2009, and for Israel the corresponding figure is 30.0%.

VAT rates in EU member states (%)

Country	1976	1987	2012	
			standard	**reduced**
Austria	18	20	20	10, 12
Belgium	18	19	21	6, 12
Denmark	15	22	25	–
France	20	18.6	19.6	2.1, 5.5
Germany	11	14	19	7
Ireland	19.5	25	23	4.8, 13.5
Italy	12	18	21	4, 10
Luxembourg		12	15	3, 6, 12
Netherlands	16	20	19	6
Spain		12	18	4, 8
Sweden	17.5	23.5	25	6, 12
United Kingdom	8	15	20	5
EU average	**15.5**	**18.2**	**20.5**	

Sources: OECD Tax Database.

VAT rates in EU member states

In the European Union, VAT rates have risen, on average, despite open borders for consumers since 1992 (which were feared to create downward tax competition for cross-border shopping).

Since 1992 there is a minimum for the standard VAT rate in the EU of 15%, but this rate is exceeded by all EU members except Luxembourg.

Almost all EU members also employ a reduced VAT rate on various items (basic foodstuffs, newspapers etc.). The only exception is Denmark where all goods are taxed at the standard rate. In the past, several EU countries also had increased VAT rates on certain luxury goods, but these had to be abolished in the course of the Commission's harmonization efforts in 1992.

Rules for rate differentiation are typically rather detailed, as the following table illustrates.

What is to come

Lecture deals with the first fundamental issue in optimal tax policy: the choice of an optimal tax structure – i.e., optimal 'relative taxes' on different tax bases.

We will consider a government that faces some amount of exogenously determined expenditures (defense, law and order, dikes, ...).

To finance these expenditures it relies on taxes on various commodities and a lump-sum tax.

We imagine an economy with identical individuals $\Longrightarrow$ no distributional concerns, only efficiency considerations.

In such a setting, what is the most efficient way of financing government expenditures?

And what if there is no lump-sum tax? Should the government differentiate commodity taxes?

OPTIMAL COMMODITY TAXATION
WITH HOMOGENEOUS HOUSEHOLDS

The model (Frank Ramsey, 1927)

For simplicity, we consider an economy with **two different goods**, c and x. All results readily generalize to a setting with many goods.

The government faces an **exogenous revenue requirement** G, which it can finance by setting commodity taxes t_c and t_x, and a lump-sum tax T.

A representative individual supplies labor l and consumes goods c and x, derives utility from consumption and disutility from work.

Given this setup, we:

1. determine equilibrium labor supply and consumption,
2. consider the effects of commodity taxes on individual behavior and deadweight losses,
3. determine optimal government policy.

Individual behavior

A **representative individual** derives utility from consumption c and x and disutility from labor supply l:

$$U = u(c, x, l), \qquad u_c, u_x > 0, \quad u_l < 0$$

Labor income net of the lump-sum tax equals $wl - T$. Commodity prices are normalized to 1 so that prices equal $1 + t_c$ and $1 + t_x$.

This yields the following **budget constraint**:

$$(1 + t_c)c + (1 + t_x)x = wl - T$$

We apply the Lagrange method of constrained optimization:

$$\mathcal{L}(c, x, l) = u(c, x, l) + \lambda \left(wl - T - (1 + t_c)c - (1 + t_x)x\right)$$

The Lagrange multiplier λ gives the utility gain of an additional \$ of income: **the marginal utility of income**

First-order conditions are given by:

$$u'_c = \lambda(1 + t_c)$$
$$u'_x = \lambda(1 + t_x)$$
$$-u'_l = \lambda w$$

- First two FOCs: utility gain of consuming one more unit (LHS) equals utility loss of the income it costs (RHS)
- Last FOC: utility loss of working one more unit (LHS) equals utility gain of extra income it generates (RHS)

Combining the first two FOCs yields:

$$\frac{u'_x}{u'_c} = \frac{1 + t_x}{1 + t_c}$$

- LHS: **Marginal rate of substitution** between x and c $=$ relative utility gain from x vs c
- RHS: Relative price of x vs c
  $\Longrightarrow$ Commodity taxes distort relative price and thereby consumption choices

Combining the first and last FOCs yields:

$$\frac{-u_l'}{u_c'} = \frac{w}{1+t_c}$$

- LHS: **Marginal rate of substitution** between leisure and c $=$ relative utility gain from leisure vs c
- RHS: Relative price of leisure vs c
  $\Longrightarrow$ Commodity tax distorts relative price and thereby labor supply decision

In general, FOCs and budget constraint imply **consumption and labor supply as function of taxes and the wage rate**:

$$c^* = c(t_c, t_x, w, T)$$
$$x^* = x(t_c, t_x, w, T)$$
$$l^* = l(t_c, t_x, w, T)$$

(In the next exercise, we will derive these functions explicitly for a specific utility function.)

The impact of taxation on individuals

As before, substituting c^*, x^* and l^* back into the utility function yields the indirect utility function $v(t_c, t_x, T) = u(c^*, x^*, l^*)$.

We could again prove **utility equivalence** (Roy's Identity):

$$v'_T = -\lambda$$
$$v'_{t_c} = -\lambda c^*$$
$$v'_{t_x} = -\lambda x^*$$

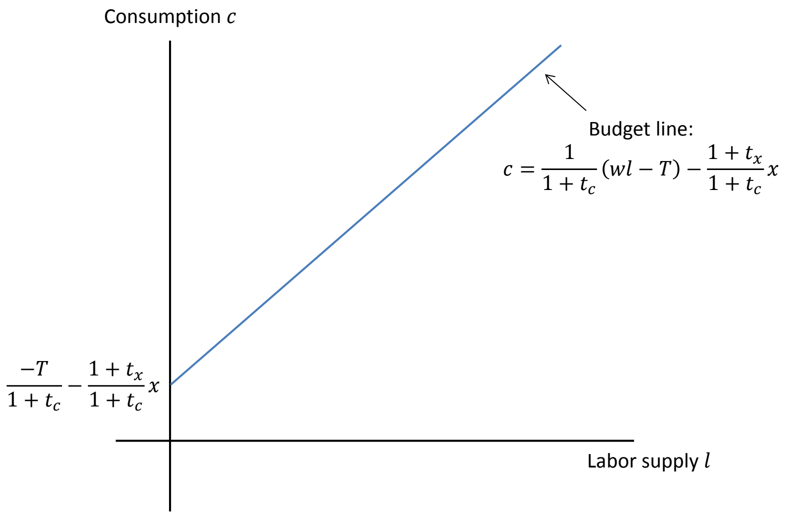
We could also again make the **Slutsky decomposition between income and substitution effects**:

$$\frac{\partial c}{\partial t_c} = \frac{\partial c^c}{\partial t_c} + c^* \frac{\partial c}{\partial T}$$
$$\frac{\partial x}{\partial t_x} = \frac{\partial x^c}{\partial t_x} + x^* \frac{\partial x}{\partial T}$$

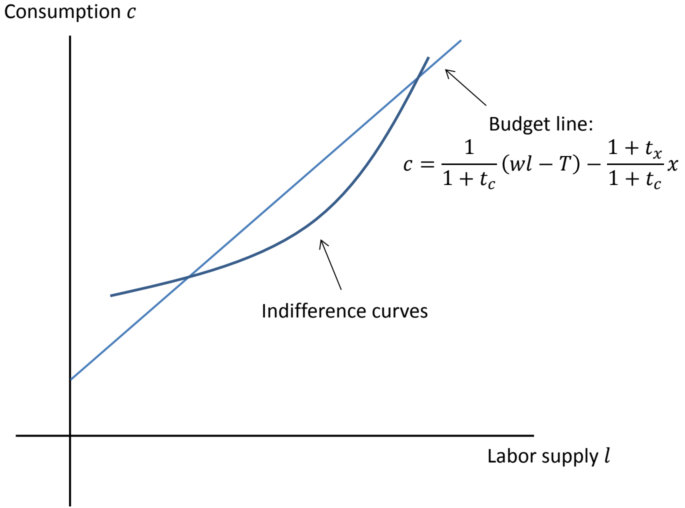
(Book also shows Slutsky decomposition for cross-price effects, where c-subscripts stand for Hicksian/compensated responses.)

Note: in the case of "normal" commodities, substitution and income effects of a tax increase are both negative (or possibly zero for the income effect). See graphs in next slides $\Longrightarrow$

Commodity taxes: income and substitution effects



Commodity taxes: income and substitution effects



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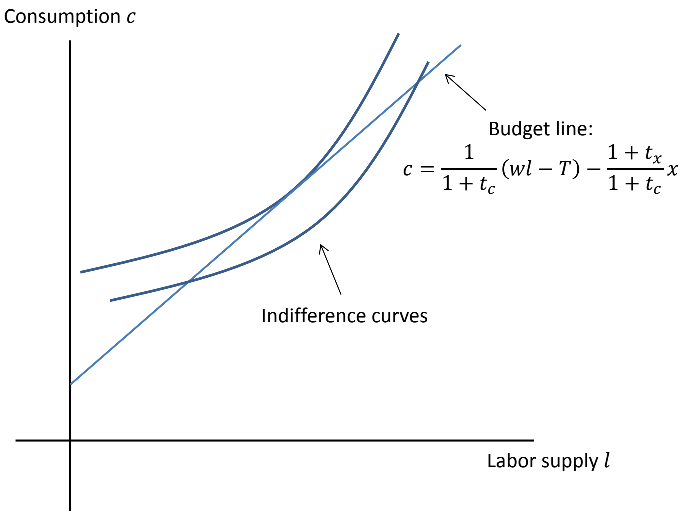

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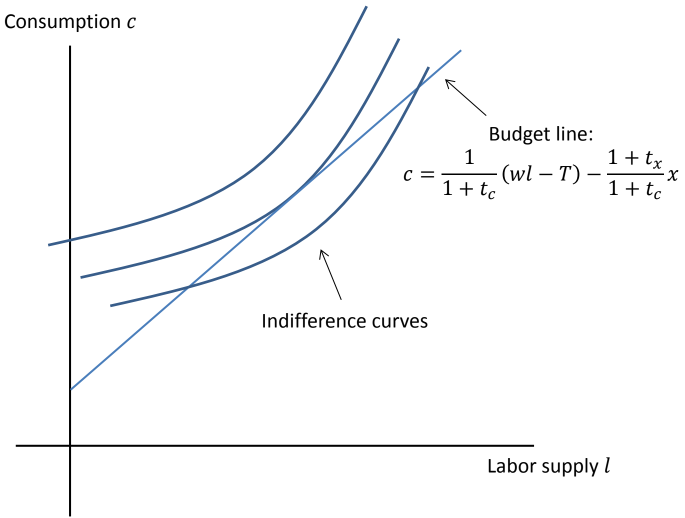

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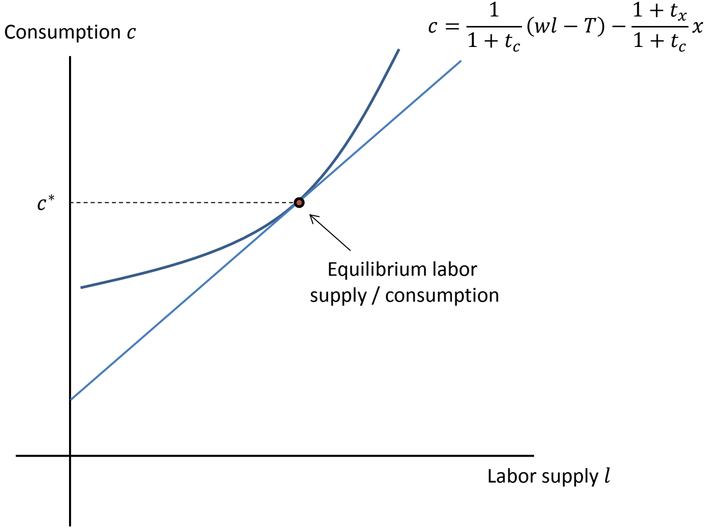

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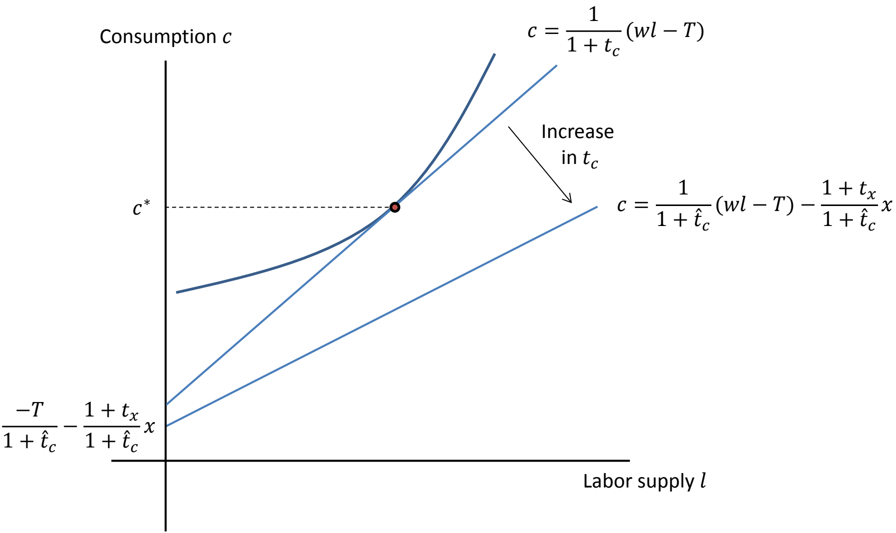

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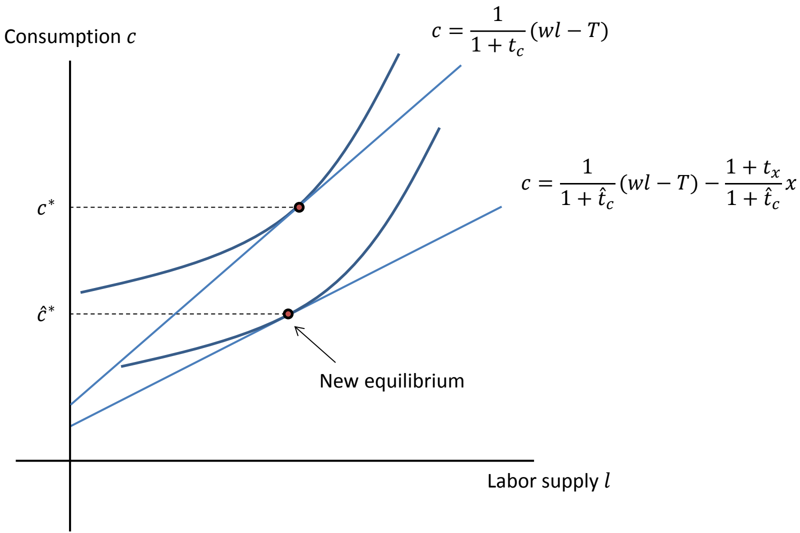

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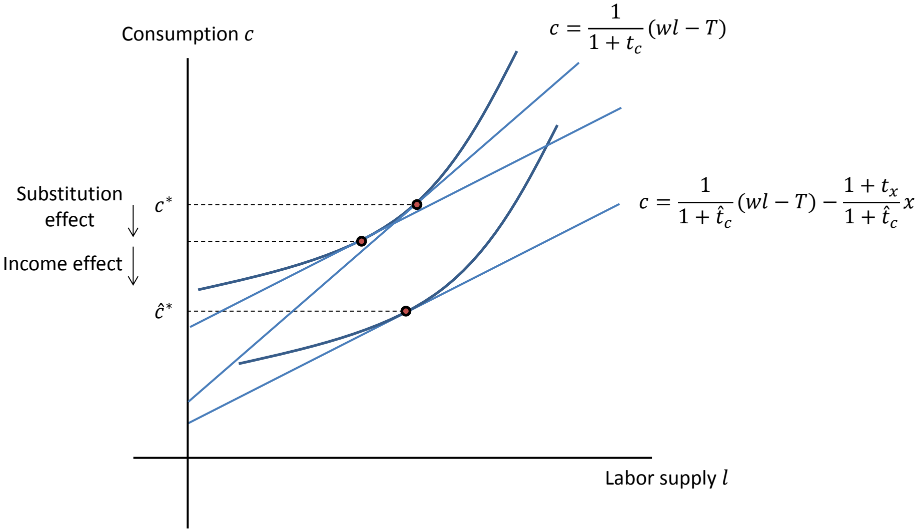

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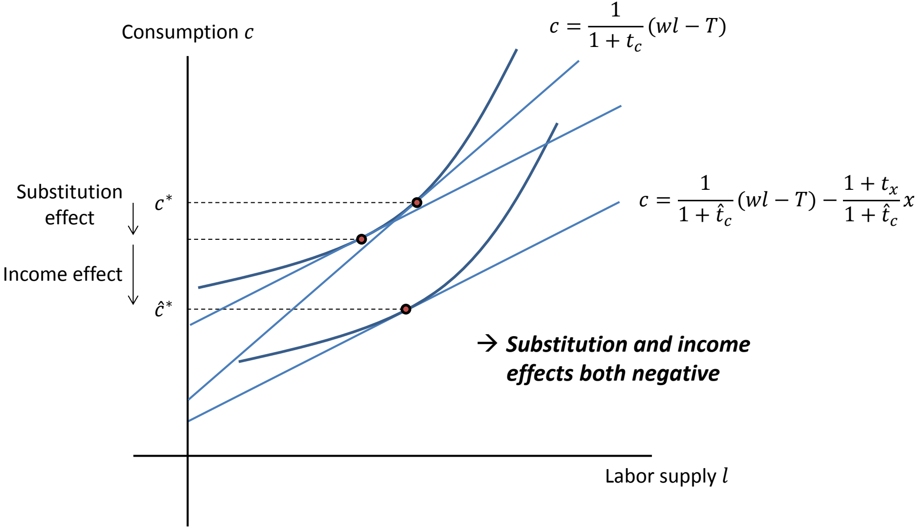
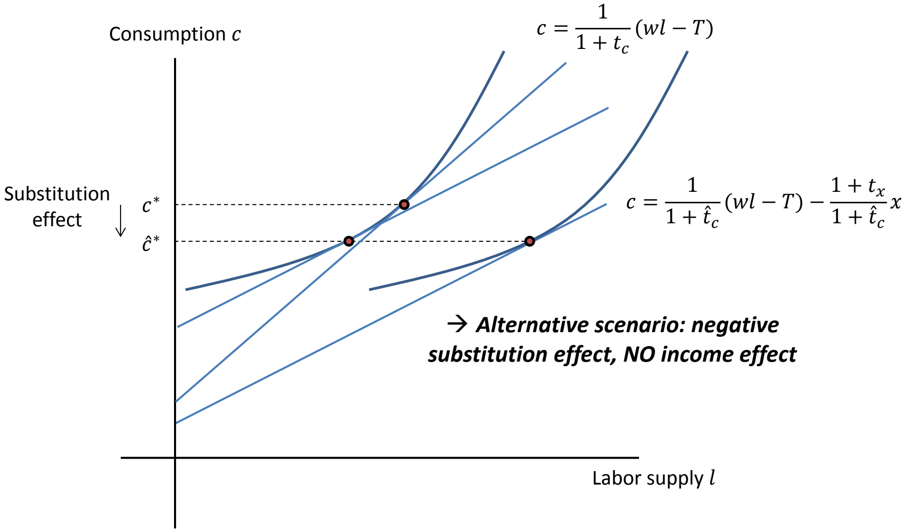


→ ***Substitution and income effects both negative***

Commodity taxes: income and substitution effects



→ ***Alternative scenario: negative substitution effect, NO income effect***

The marginal deadweight loss of commodity taxation

For now, we make an important assumption that we will relax later on: **we assume that commodity demand of one good does not depend on the price of the other good.** Moreover, we abstract from income effects on consumption (not crucial):

$$c^* = c(t_c, w)$$
$$x^* = x(t_x, w)$$

We can once more determine the distortive effects of commodity taxes by deriving their **marginal deadweight loss**: *what is the revenue loss associated with raising 1 of revenue with t_c (or t_x), while compensating individuals in a lump-sum manner.*

Thus, the MDWL measures the efficiency loss of raising revenue with t_c (t_x) rather than with T.

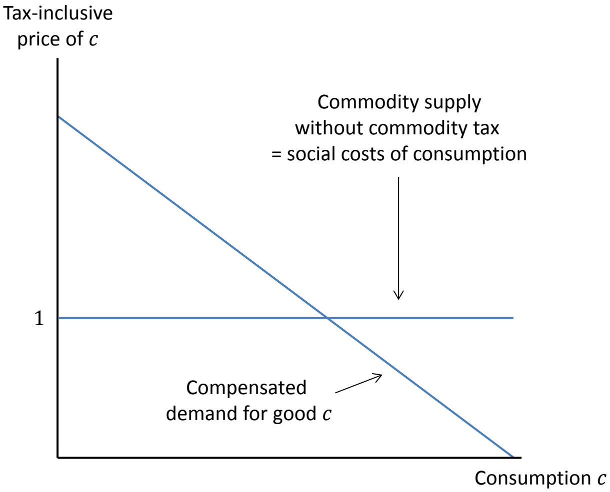
To calculate the MDWL of t_c and t_x, we first define the **(compensated) price elasticities of commodity demand**:

$$
\begin{aligned}
e_{ct_c} &= -\frac{\partial c^c}{\partial t_c}\frac{1+t_c}{c} > 0 \\
e_{xt_x} &= -\frac{\partial x^c}{\partial t_x}\frac{1+t_x}{x} > 0
\end{aligned}
$$

Note: elasticities are defined to be positive.

In the next slides, we graphically determine the MDWL of a commodity tax $\Longrightarrow$

Marginal dead-weight loss of commodity taxation



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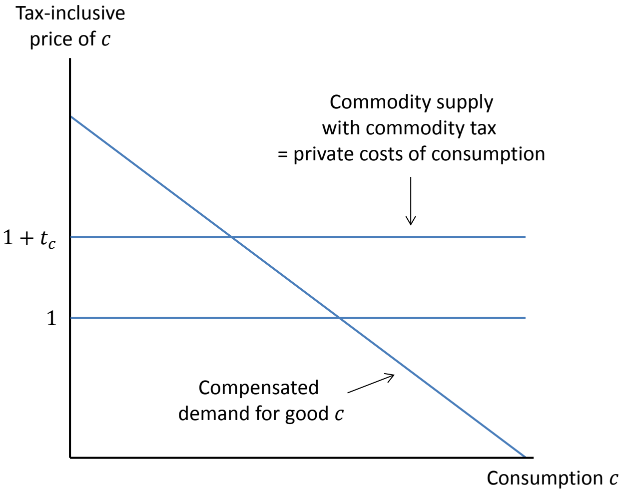

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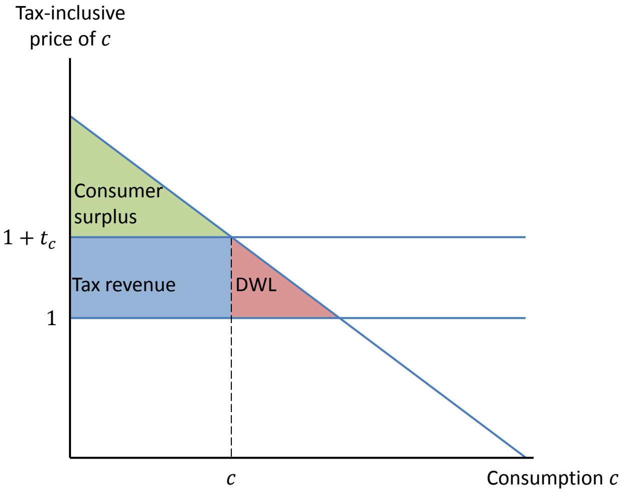

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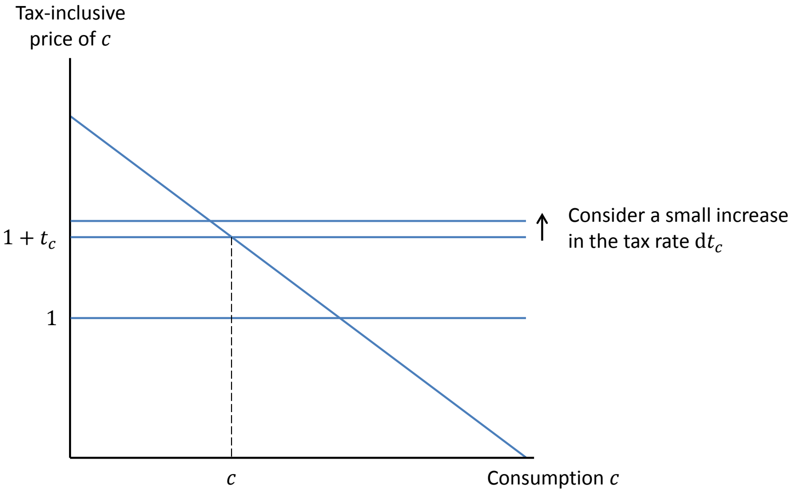

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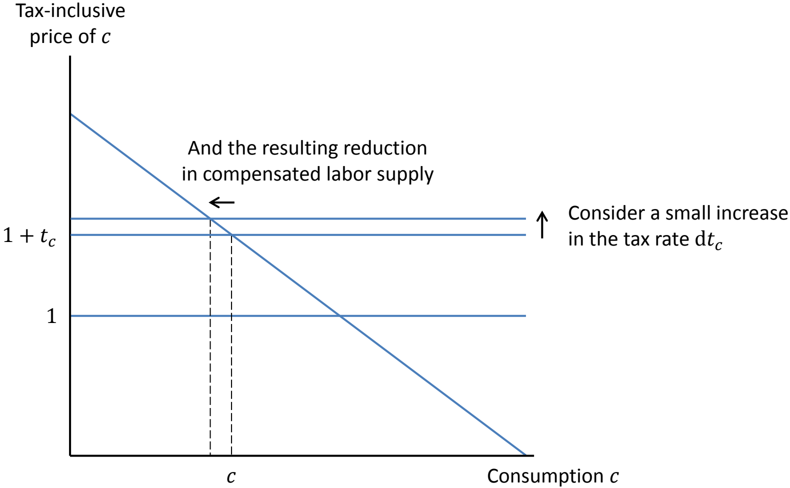

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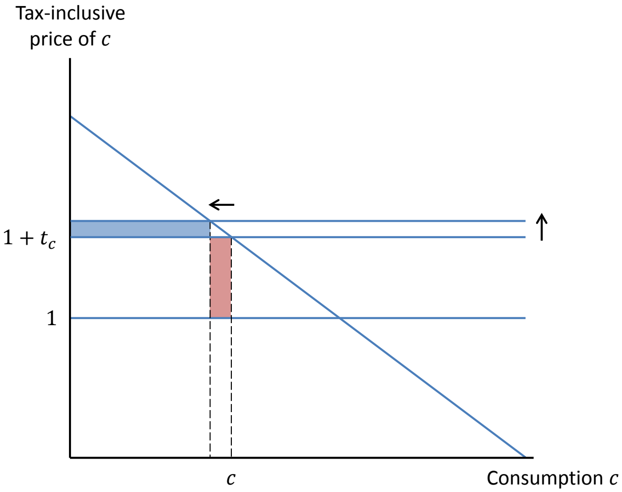

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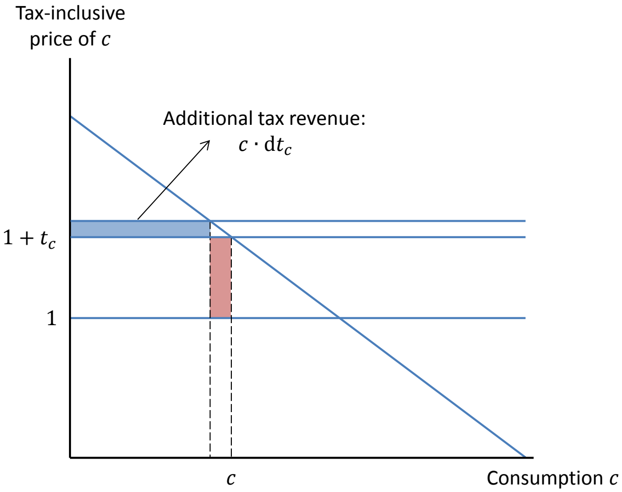

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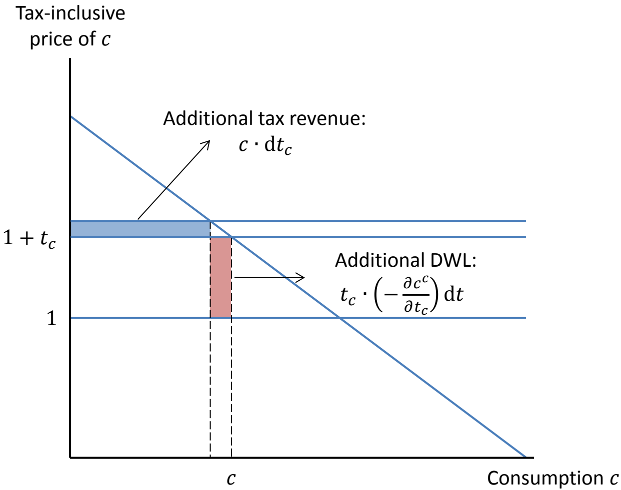

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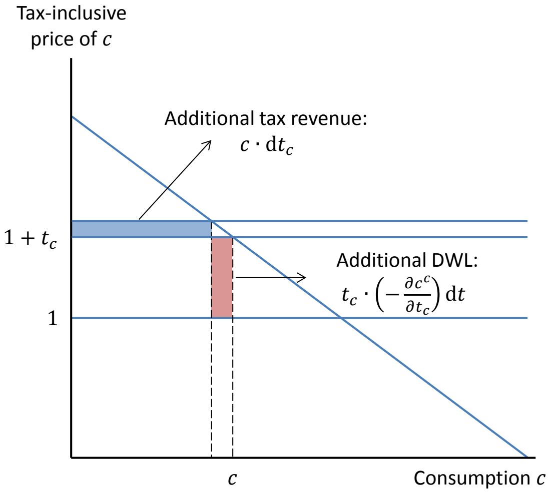


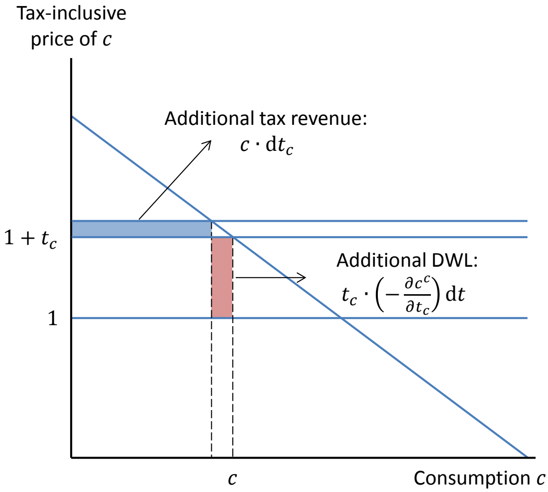
Marginal dead-weight loss equals additional DWL per additional unit of tax revenue:

$$MDWL_{t_c} = \frac{t_c}{1+t_c} \cdot \left(-\frac{\partial c^c}{\partial t_c} \frac{1+t_c}{c}\right)$$

Or, substituting for the elasticity:

$$MDWL_{t_c} = \frac{t_c}{1+t_c} \cdot e_{ct_c}$$

Marginal dead-weight loss of commodity taxation



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Or, substituting for the elasticity:

$$MDWL_{t_c} = \frac{t_c}{1+t_c} \cdot e_{ct_c}$$

Similarly, for the marginal dead-weight loss of t_x we could write:

$$MDWL_{t_x} = \frac{t_x}{1+t_x} \cdot e_{xt_x}$$

The marginal deadweight loss of commodity taxation is given by:

$$MDWL_{t_c} = \frac{t_c}{1+t_c} \cdot e_{ct_c}$$
$$MDWL_{t_x} = \frac{t_x}{1+t_x} \cdot e_{xt_x}$$

Similar to income taxation, the MDWL of commodity taxation is:

- increasing in the commodity tax rate
- increasing in the compensated price elasticity of demand

(In the more general case in which demand for one commodity depends on the price of the other commodity, the MDWL measures also depend on cross-price effects.)

Optimal government policy

The social welfare function is straightforward because there is only one representative individual:

$$\mathcal{W} = v(t_c, t_x, T)$$

The government maximizes social welfare w.r.t. the tax rates and subject to the following **government budget constraint**:

$$t_c c^* + t_x x^* + T = G$$

Set up the **Lagrangian**:

$$\mathcal{L} = v(t_c, t_x, T) + \eta(t_c c^* + t_x x^* + T - G)$$

Notice that the Lagrange multiplier η measures the social welfare gain (=utility gain) of an additional $ of government revenue: **the marginal utility of government revenue**.

First-order conditions w.r.t. T, t_c, t_x are given by:

$$\frac{\mathrm{d}\mathcal{L}}{\mathrm{d}T} = 0 \quad \Longrightarrow \quad v'_T + \eta = 0$$
$$\frac{\mathrm{d}\mathcal{L}}{\mathrm{d}t_c} = 0 \quad \Longrightarrow \quad v'_{t_c} + \eta \left(c^* + t_c \frac{\partial c}{\partial t_c} \right) = 0$$
$$\frac{\mathrm{d}\mathcal{L}}{\mathrm{d}t_x} = 0 \quad \Longrightarrow \quad v'_{t_x} + \eta \left(x^* + t_x \frac{\partial x}{\partial t_x} \right) = 0$$

- First terms on RHS: welfare loss from higher tax burdens for individuals (utility loss)
- Second terms on RHS: welfare gain from higher tax revenue *absent behavioral responses*
- Third term on RHS (for the last 2 FOCs): welfare loss from lower tax revenue *due to behavioral responses*

Next step: plug in individual incentives into the FOCs of the policy-maker's problem and rearrange in a nice way.

Substitute for $v'_T = -\lambda$, $v'_{t_c} = -\lambda c^*$, and $v'_{t_x} = -\lambda x^*$, for the definitions of the elasticities, and rearrange to get:

$$
\begin{aligned}
0 &= 1 - \lambda/\eta && \text{[FOC } T\text{]} \\
\frac{t_c}{1+t_c} e_{ct_c} &= 1 - \lambda/\eta && \text{[FOC } t_c\text{]} \\
\frac{t_x}{1+t_x} e_{xt_x} &= 1 - \lambda/\eta && \text{[FOC } t_x\text{].}
\end{aligned}
$$

- **With lump-sum taxes**: $t_c = t_x = 0$, and $\lambda = \eta$

$\Longrightarrow$ $t_c = t_x = 0$ implies that the government does **not** want to impose distortive commodity taxes if it can finance its revenue requirement with a non-distortive lump-sum tax

$\Longrightarrow$ $\lambda = \eta$ implies that an extra \$ in the hands of the government has the same worth as an extra \$ in the hands of individuals

Substitute for $v'_T = -\lambda$, $v'_{t_c} = -\lambda c^*$, and $v'_{t_x} = -\lambda x^*$, for the definitions of the elasticities, and rearrange to get:

$$
\begin{aligned}
0 &= 1 - \lambda/\eta && \text{[FOC } T\text{]} \\
\frac{t_c}{1+t_c} e_{ct_c} &= 1 - \lambda/\eta && \text{[FOC } t_c\text{]} \\
\frac{t_x}{1+t_x} e_{xt_x} &= 1 - \lambda/\eta && \text{[FOC } t_x\text{]}.
\end{aligned}
$$

- **Without lump-sum taxes**: $t_c, t_x > 0$, and $\lambda < \eta$

$\Longrightarrow$ $t_c, t_x > 0$ implies that the government has to rely on distortive taxes if it has no access to the lump-sum tax

$\Longrightarrow$ $\lambda < \eta$ implies that a \$ in the hands of the government is worth **more** than a \$ in the hands of individuals $\Longrightarrow$ because the government can give this \$ to individuals **while at the same time reduce distortions** by lowering commodity taxes

With optimally positive commodity taxes, should government set **uniform commodity taxes** or **differentiated rates**?

Note that we can rewrite the FOCs for t_c and t_x as:

$$\frac{t_c}{1+t_c} e_{ct_c} = MDWL_{t_c} = MDWL_{t_x} = \frac{t_x}{1+t_x} e_{xt_x}$$

$\Longrightarrow$ First (general) result on optimal commodity taxation: The government sets both taxes such that the **distortions per additional unit of tax revenue (MDWL) are equalized across tax instruments**

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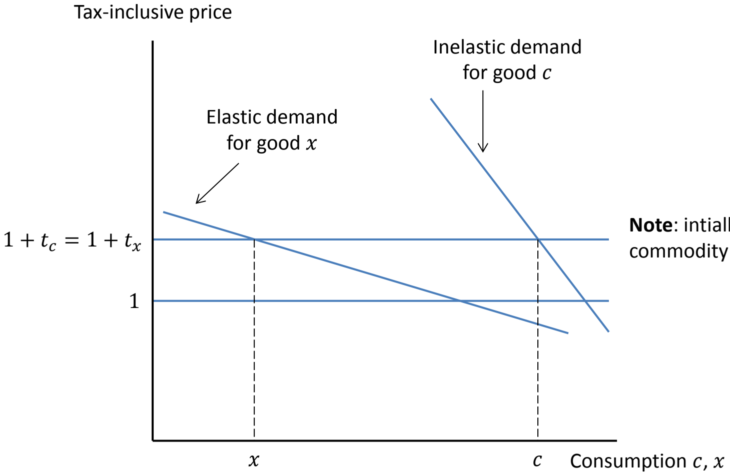
$\Longrightarrow$ First (general) result on optimal commodity taxation: The government sets both taxes such that the **distortions per additional unit of tax revenue (MDWL) are equalized across tax instruments**

We can further write:

$$\frac{t_c}{1+t_c} = \frac{1-\lambda/\eta}{e_{ct_c}}; \qquad \frac{t_x}{1+t_x} = \frac{1-\lambda/\eta}{e_{xt_x}}$$

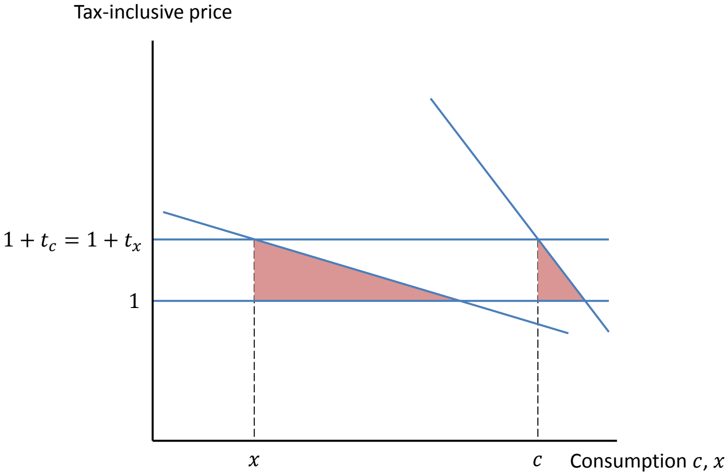
$\Longrightarrow$ Second (less general) result on optimal commodity taxation, **Ramsey's inverse elasticity rule**: Optimal commodity taxes are decreasing in the own-price elasticity of consumption (also see graphs on the next slide)

The optimality of differentiated commodity taxes

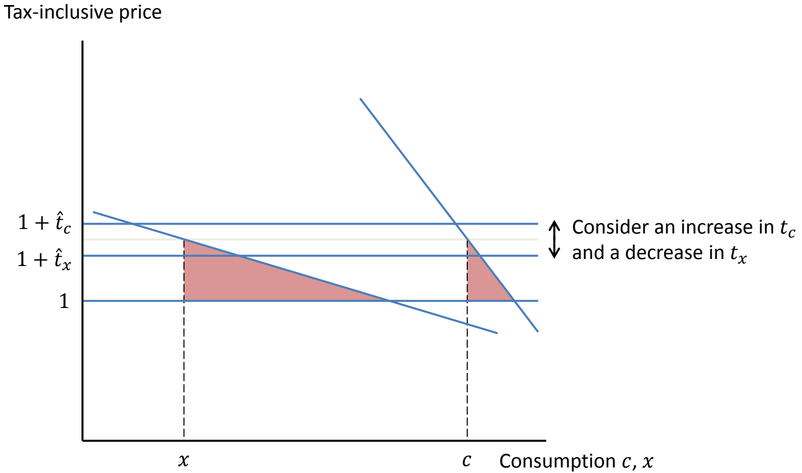


Note: intially uniform commodity taxes

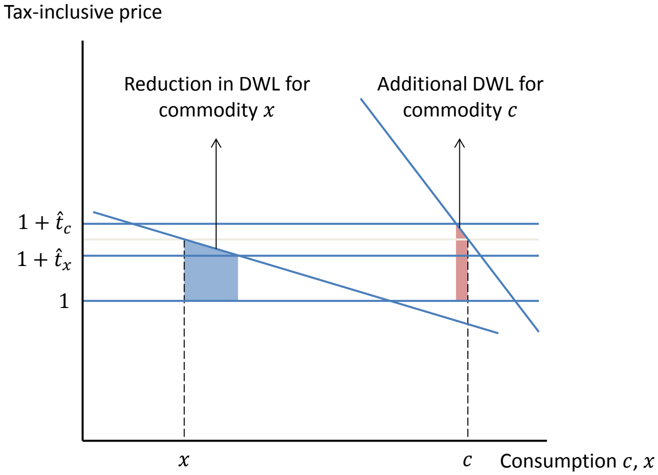
The optimality of differentiated commodity taxes



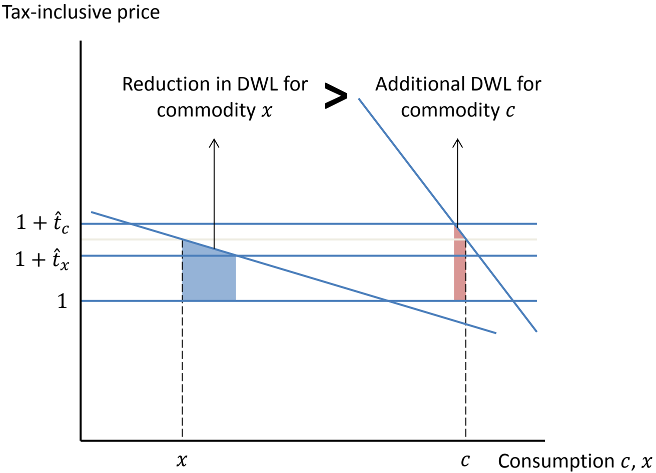
The optimality of differentiated commodity taxes



The optimality of differentiated commodity taxes



The optimality of differentiated commodity taxes



Corlett-Hague rule of optimal commodity taxation

So what if we relax the assumption of no cross-price effects?
It turns out that the inverse-elasticity rule is **not robust**.

First, let us define the compensated wage-elasticities of commodity demands c and x as follows:

$$e_{cw} \equiv \frac{\partial c^c}{\partial w}\frac{w}{c}$$
$$e_{xw} \equiv \frac{\partial x^c}{\partial w}\frac{w}{x}$$

- If $e_{cw} > 0$, then commodity c is a complement to labor / substitute of leisure
- If $e_{xw} > 0$, then commodity x is a complement to labor / substitute of leisure
- If $e_{cw} > e_{xw}$, then commodity c is **more complementary** to labor than commodity x

Given this notation, we can finally formulate the following result (see book for full derivation)

The general result of optimal commodity taxation is known as the **Corlett-Hague rule**, after Corlett and Hague (1953):

$$\frac{t_c/(1+t_c)}{t_x/(1+t_x)} = \frac{-e_{cw} + (e_{ct_c} + e_{xt_x})}{-e_{xw} + (e_{ct_c} + e_{xt_x})}$$

Equivalently, subtracting 1 from either side, we can write:

$$\frac{t_c/(1+t_c) - t_x/(1+t_x)}{t_x/(1+t_x)} = \frac{e_{xw} - e_{cw}}{(e_{ct_c} + e_{xt_x}) - e_{xw}}.$$

In the optimum, $t_c > t_x$ if and only if $e_{cw} < e_{xw}$ and thus if and only if commodity c is more complementary to leisure than commodity x.

Corlett-Hague rule: Higher tax rates on relative leisure complements; lower tax rates on relative labor complements

Interpretation of the Corlett-Hague rule

Commodity taxes distort the consumption/leisure decision by driving a wedge between the private and social costs of consumption relative to leisure

$\Longrightarrow$ households take up too much leisure/supply too little labor from a social point of view

Taxing relative complements of leisure indirectly raises the price of leisure, thereby alleviating the pre-existing distortion on labor

Notice that non-uniform consumption taxes do create distortions in goods markets $\Longrightarrow$ optimally trade off lower distortions on the labor market with lower distortions on good markets

Prime example: **child care** is highly complementary to labor and should therefore receive low taxes/high subsidies

$\Longrightarrow$ but what about other goods? largely an open empirical question ($\rightarrow$ see next Section)

Underlying assumption of the Corlett-Hague rule: taxing leisure is technically impossible. Indeed, if government had access to a tax on leisure, it could mimic a lump-sum tax by taxing all commodities and leisure at a uniform rate leisure tax

Thus, optimal non-uniformity of consumption taxes is fundamentally driven by assumptions of no lump-sum tax AND unobservability/untaxability of leisure

A final note: the Corlett-Hague rule is remarkably robust! Even when we allow for income inequality and nonlinear income taxes, commodity taxes should only be differentiated according to goods' relative complementarity with leisure.

Homework, to be discussed in the next class: Exercise 6.14.2 in Jacobs (2017).

Further reasons to differentiate commodity taxes: corrective taxation

So far, we have assumed that there is **no market failure**. In particular, we have assumed that there are no externalities:

Externality – an externality is present whenever an individual does not fully take into account some of the costs or benefits *to others* when making economic decisions

In reality, a number of important commodities impose external costs on others (also see Jacobs, 2015, chapter 8):

- carbon emissions and global warming
- congestion externalities from driving a car
- sound and air pollution of airplanes
- status effects (rat race) when people car about relative income
- ...

In the presence of an externality, the market equilibrium is no longer efficient because of a **pre-existing distortion**: even absent taxation, there is a wedge between the marginal *social* costs (or benefits) of consumption and the marginal *private* costs (or benefits) of consumption.

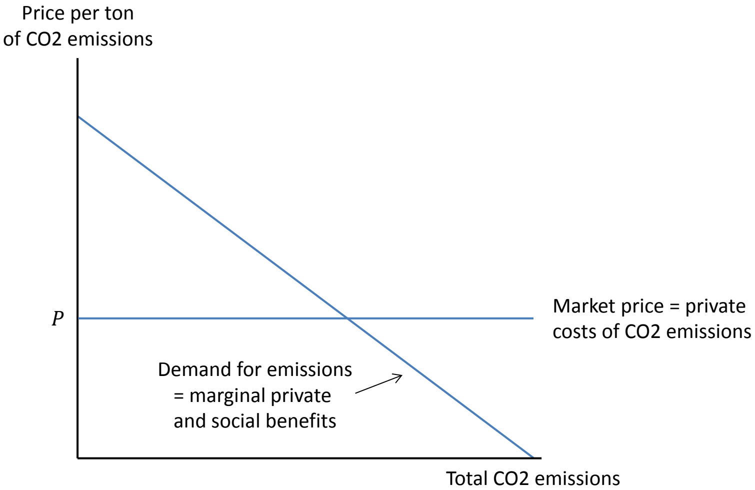
For example, a recent study has quantified the external costs of CO2 emissions associated with global warming at about $33 per ton of emissions (IAWG, 2013):

$\Longrightarrow$ implies that the marginal social costs of CO2 emissions are $33 per ton higher than the marginal private costs!

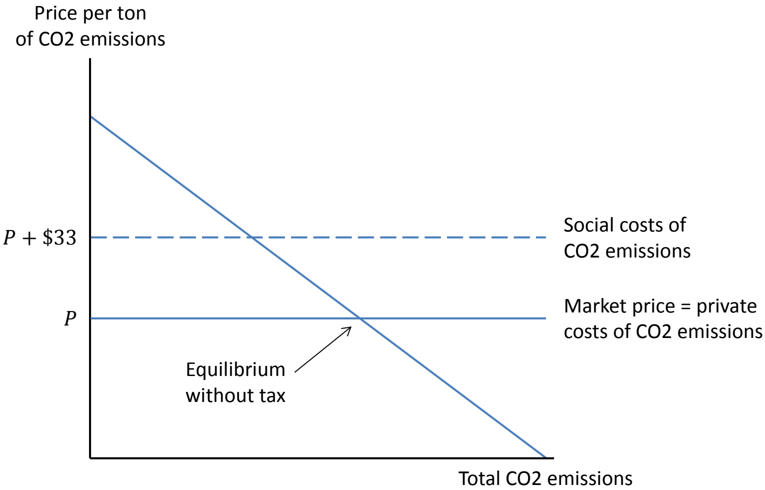
$\Longrightarrow$ unchecked, this implies that individuals will emit more CO2 than is socially optimal

Ever since Arthur C. Pigou (1920), the default solution to externalities is a **corrective tax**, or **Pigouvian tax** $\Longrightarrow$ equalize social and private costs by imposing a tax on carbon emissions of $33 per ton!

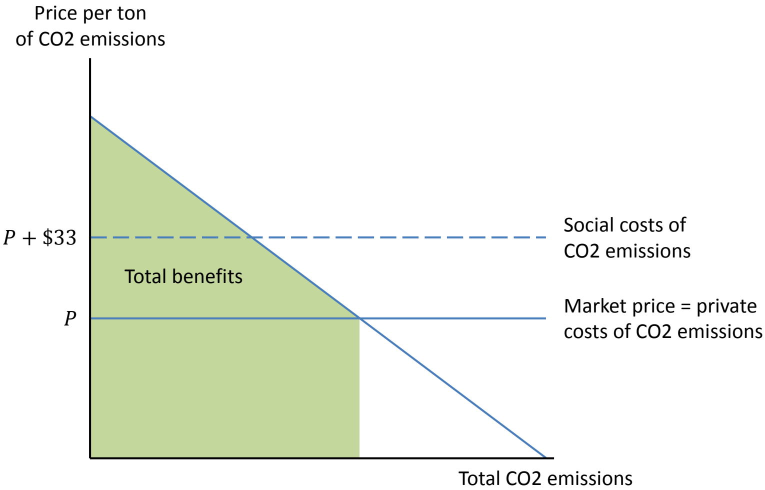
Corrective taxation of an externality



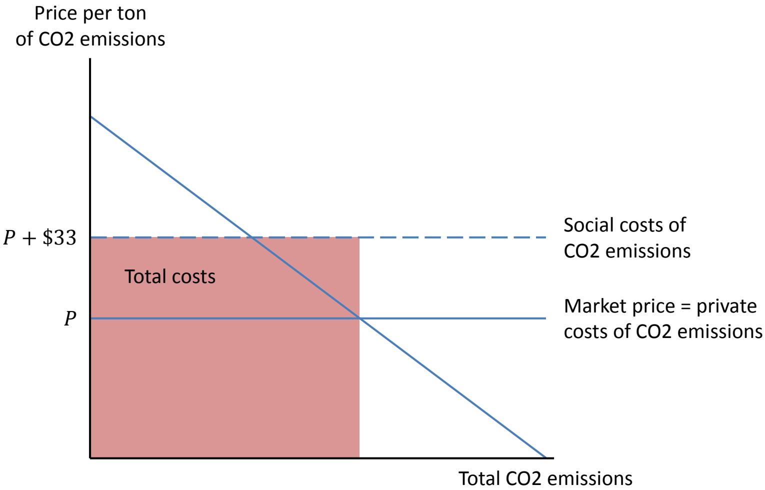
Corrective taxation of an externality



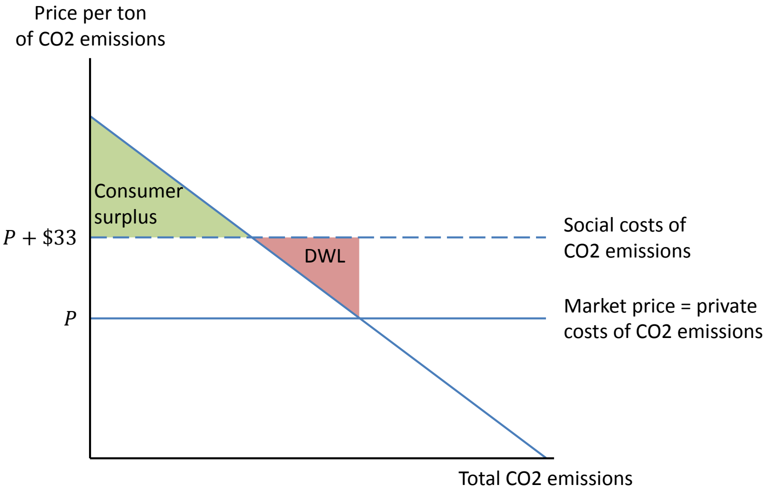
Corrective taxation of an externality



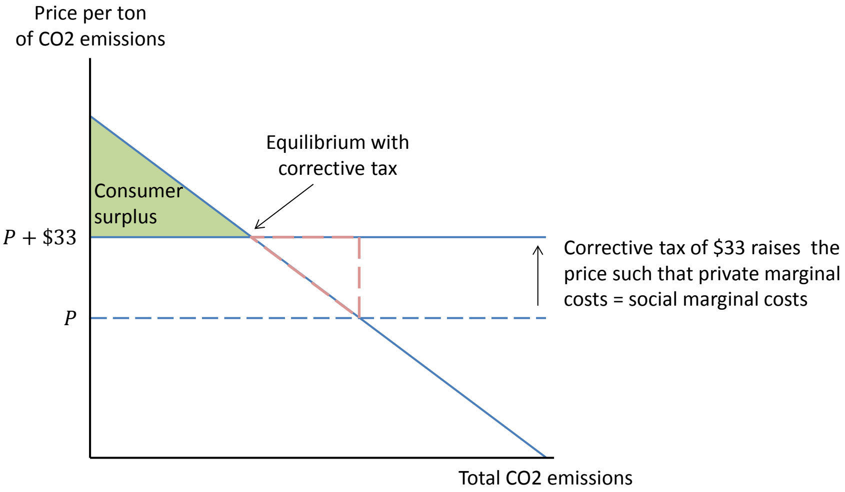
Corrective taxation of an externality



Corrective taxation of an externality



Corrective taxation of an externality



Since the advent of **behavioral economics**, economists spend a lot of effort in understanding deviations from utility maximization. For example:

- For tomorrow, I prefer to eat an apple over a bag of chips (long-term preferences)
- But whenever tomorrow actually arrives, I prefer the bag of chips over the apple (short-term preferences)

If my long-term preferences correspond better to my welfare than my short-term preferences, I suffer from a **present bias**: I attach too much importance to immediate gratification and too little importance to delayed costs and benefits of consumption.

More generally, individual behavior might suffer from an internality:

Internalities – an internality is present whenever an individual does not fully take into account some of the costs or benefits *to himself* when making economic decisions

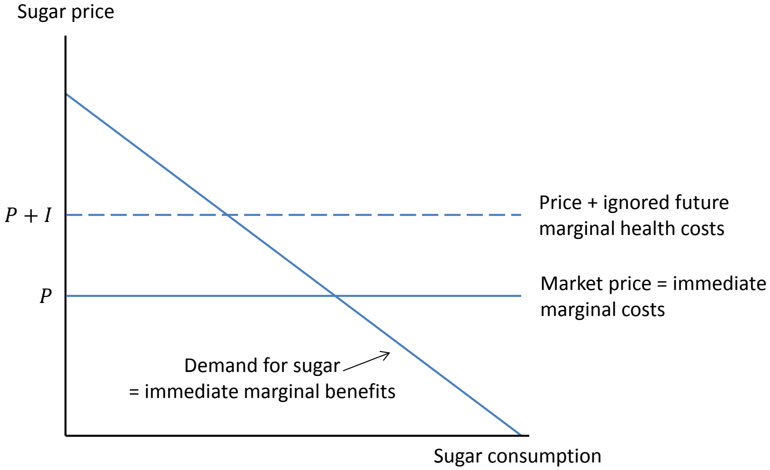
Many types of economic behavior may be affected by internalities:

- sugar consumption – when consumers are ignorant of its effects on obesity and associated diseases
- alcohol, tobacco, and other addictive drugs – when consumers are in denial about their addictiveness
- saving for retirement – when consumers overweigh the immediate gratification of current consumption
- labor effort – when the immediate gratification of slacking are overweighed compared to future promotions and bonuses
- ...

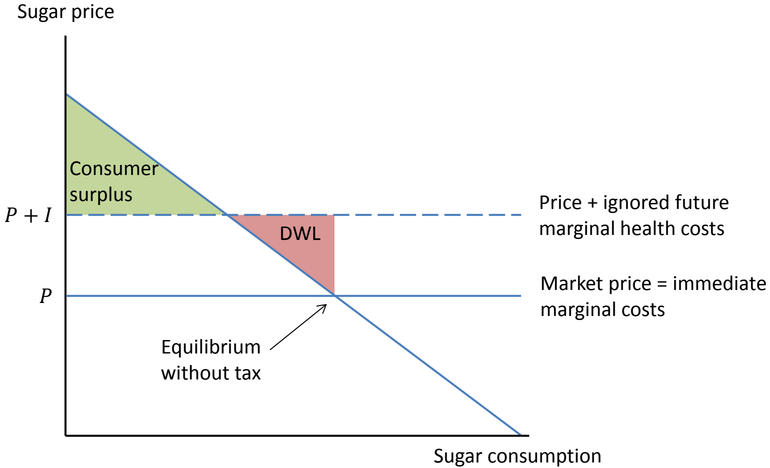
Some economists apply logic of corrective taxation to internalities:

- if consumers ignore 20% of the costs of sugar because they do not know that sugar consumption might cause overweight, the *actual* private costs of sugar are 20% higher than what consumers *perceive to be* the private costs
- efficient consumption decisions can be achieved by a 20% tax on sugar (as proposed, e.g., by the World Health Organization, 2015)

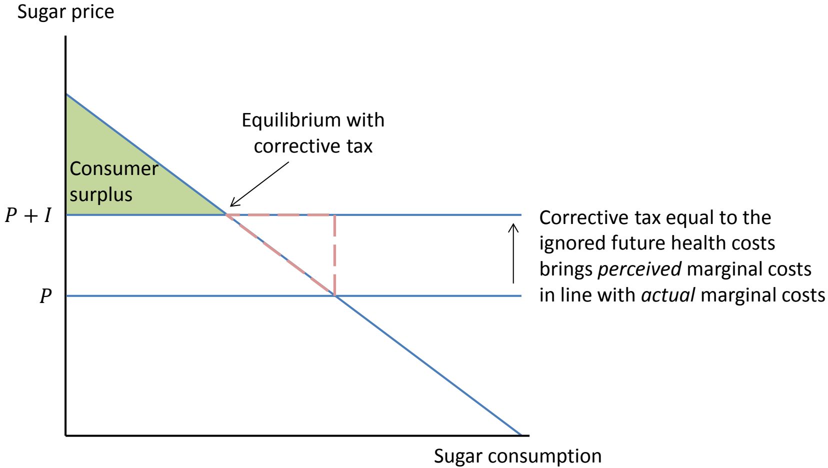
Corrective taxation of an *internality*



Corrective taxation of an *internality*



Corrective taxation of an *internality*



However, contrary to Pigouvian taxation, corrective taxation of internalities is controversial for at least four reasons:

1. It is typically very difficult to establish the existence of an internality, let alone quantify its importance
2. Corrective taxes of internalities might be badly targeted – for example, chain smokers who suffer from an internality might be less responsive to taxes than casual smokers who do not suffer from an internality
3. Corrective taxes of internalities might be very regressive – for example, both sugar and tobacco are disproportionately consumed by the poor
4. Whether the government ought to protect individuals from themselves is politically and philosophically much more controversial than whether government ought to protect individuals from others

EMPIRICAL ESTIMATIONS OF LEISURE COMPLEMENTARITY

Estimating gasoline's leisure complementarity (West and Williams, 2007)

Purpose of the paper

- Direct application of the Corlett-Hague rule: estimate the cross-price elasticity between gasoline and leisure. Are they complements (driving for leisure) or substitutes (driving to work)?
- Add this optimal-tax component to the optimal Pigouvian tax on gasoline for reasons of environmental externalities.
- Policy importance: Gasoline consumption is an important commodity, and it is subject to specific taxation (i.e., it is not only part of a general consumption tax system).
- Novelty: Almost all previous work that dealt with Pigouvian aspects of gasoline taxation has assumed specific utility functions under which all goods are equally complementary to leisure.

The empirical model – based on the Almost Ideal Demand System (AIDS) of Deaton and Muellbauer (1980)

A household's expenditure share on gasoline – good x – depends on prices, wages and income as follows:

$$s_x = \alpha_x + \gamma_{xp_x} \ln p_x + \gamma_{xp_c} \ln p_c + \gamma_{xw} \ln w + \beta_x \ln Y$$

where p_x is the price of gasoline, p_c is the price of other goods, w is the wage rate (price of leisure), and Y is real income.

Similar equations for 'other goods' and 'leisure.'

Question: under which parameter values for the αs, γs, and βs, does the demand system best fit the observed data on U.S. households' expenditure shares, hours, prices, and income?

And what do these estimates imply for own- and cross-price elasticities?

compensated price elasticities			
	gas price	wage rate	other price
gasoline	-0.750	**0.180**	0.586
labor	-0.009	0.353	-0.296
other	0.016	**0.203**	-0.209

Estimation results:

- Compensated wage-elasticity of gasoline demand is positive $\Longrightarrow$ gasoline is complement of labor / substitute of leisure
- But smaller than that of other goods $\Longrightarrow$ gasoline is *relatively* complementary to leisure

$\Longrightarrow$ **Corlett-Hague argument for higher taxes on gasoline over and above the optimal Pigouvian tax**

Quantification of optimal tax rates:

- The authors take estimate for Pigouvian tax from the environmental economics literature: Pigouvian tax should be 76 U.S. cents/ gallon (3.8 liters) in 1997 prices.
- The authors estimate the optimal tax including the relative complementarity with leisure to be about 82 cents/gallon for one-adult households (table above) and 130 cents/gallon for two-adult households. Hence in some settings the optimal tax is much higher than the Pigouvian component.
- However, results must be interpreted with caution and might be time and country specific ($\rightarrow$ see next study)

Estimates from the Mirrlees Review

The Mirrlees Review (2010) provides an extensive review of the British tax system.

Chapter 4 by Crawford, Keen and Smith (2010) performed a similar exercise as above, this time for the United Kingdom and including more commodities.

They estimated the effect on a commodity's expenditure share of an additional hour worked $\implies$ a measure of the relative complementarity between commodity demand and labor.

Results are on the next slide.

Table 4.1. Estimates of commodity demand complementarities with leisure (Crawford, Keen, and Smith (2008))

	Impact on budget percentage share of an additional hour worked (t statistics in brackets)	
Bread and cereals	−0.024	(64.3)
Meat and fish	−0.060	(−49.2)
Dairy products	−0.045	(−66.6)
Tea and coffee	−0.008	(−29.5)
Fruit and vegetables	−0.037	(−52.8)
Other zero-rated foods	−0.020	(−28.1)
Standard-rated foods	−0.027	(−40.0)
Food eaten out	0.054	(38.5)
Beer	0.020	(13.3)
Wine and spirits	0.020	(21.2)
Tobacco	−0.026	(−16.6)
Domestic fuels	−0.049	(−30.6)
Household goods and services	0.064	(24.2)
Adult clothing	0.000	(−0.0)
Childrens' clothing	−0.006	(−8.7)
Petrol and diesel	0.046	(35.9)
Public transport	−0.006	(−6.2)
Leisure goods	0.019	(9.4)
Books and newspapers	−0.001	(−2.0)
Leisure services	0.086	(28.1)

Note: Results from demand system estimates reported by Crawford, Keen, and Smith (2008), based on household micro-data from 22 years of the UK Family Expenditure Survey (1978–99). The table shows the impact of an additional hour worked on the budget (percentage) share of each commodity group in household spending. Thus, for example, an additional hour worked reduces the (average) percentage of households' spending devoted to bread and cereals by 0.024 points. Commodities for which the coefficient is negative are leisure complements, and those for which the coefficient is positive are leisure substitutes. All coefficients except that on adult clothing are significantly different from zero, implying that weak separability is firmly rejected.

Findings of Crawford, Keen and Smith (2010):

- Relatively complementary to *leisure*: foodstuffs, domestic fuels, tobacco
- Relatively complementary to *labor*: leisure services* (!), petrol and diesel, food eaten out, alcohol drinks

However, they find that effects are relatively small (and uncertain) to justify the costs that come from VAT differentiation: e.g., more complicated tax system and larger scope for tax evasion.

* They explain this as "perhaps reflecting the use of such goods as substitutes for time in producing relaxation, in line with household production considerations" (p.289)

Further findings

Child care has been shown to be a relative **complement of labor** in Finland (Pirttilä and Suoniemi, 2014)

Housing expenditure and **mortgage payments** have been shown to be relative **complements of leisure** in both Finland and the U.S. (Pirttilä and Suoniemi, 2014; Gorden and Kopczuk, 2014)

Future consumption (savings) has also been shown to be a relative **complement of leisure** in Finland and the U.S. (Pirttilä and Suoniemi, 2014; Gorden and Kopczuk, 2014)

These studies would justify **subsidies on child care**, and **taxes on housing and savings**.

Overall, however, too little research has been done on this crucial topic $\Longrightarrow$ ripe for future PhDs!

SUMMING UP

Key insights from the Lecture

Main lessons for the optimal taxation of commodities:

1. In the optimum, the government equalizes the marginal excess burden of different commodity taxes
2. Efficiency considerations prescribe higher taxes on goods that are relatively complementary to leisure in order to reduce distortions in the labor market (Corlett-Hague rule)
3. On top of that, corrective taxes are called for when externalities (or internalities) cause markets to fail
4. Empirical evidence on commodities' relative complementarity to leisure is scarce and indecisive except for certain special cases (e.g., child care)

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APPENDIX

A tax on leisure

Denote the household's **total time endowment** by $\Omega \longrightarrow$ leisure is given by $\Omega - l$

Note that a household's **full income** is given by $w\Omega =$ the income it would earn when supplying the highest feasible amount of labor – furthermore note that $w\Omega$ is exogenously given so does not depend on behavior

Now imagine leisure is taxed at a rate t_l; the household's budget constraint can then be written as:

$$(1 + t_c)c + (1 + t_x)x + (1 + t_l)w(\Omega - l) = w\Omega$$

A uniform tax on all three goods would now be equivalent to a tax on $w\Omega$, and thus to a lump-sum tax $T = \tau w\Omega$. To see this, set $t_c = t_x = t_l = \frac{\tau}{1-\tau}$. Substitute and rearrange to get:

$$c + x = wl - \tau w\Omega$$

go back