

Economics 244: Macro Modeling

Corrective Taxation: Externalities

José Víctor Ríos Rull

Spring Semester 2020

Most Material developed by Hilary Hoynes (UC-Davis) and Kate Smith (IFS)

University of Pennsylvania

WHAT ARE EXTERNALITIES? I

- An externality arises whenever the utility or production possibility of people or firms depend directly on the actions of others.
- Directly means that the effect is not transmitted through prices (i.e., through a market mechanism).
- **Examples:**
 - Pollution/loud music: these externalities enter directly into the utility or production functions of others.
 - Consumption of an apple: pecuniary externality, internalized in market prices.
- “Non-pecuniary” vs. “Pecuniary” definition. Depends fundamentally on markets that are in place.
- We are only concerned about the “Non-pecuniary” externalities. The other ones are not really externalities.

WHAT ARE EXTERNALITIES? II

- The presence of externalities depends in details of the institutional arrangement like definition of commodities and property rights.
- **Example:** Consider 2 firms, 1 firm pollutes the river and the second firm is a fish farm on that river that suffers from pollution of firm 1. If the two firms merge or if one owns the river and can charge the other for pollution, then external effect gets internalized and there is no longer an externality.
- Old Chicago view (Coase): Can convert all externalities into pecuniary externalities with appropriate markets. It really does not work as there is a lot of market power. (bridge fees).
- Connection with public goods. Public goods are goods that have large-scale productive externalities.

KEY QUESTIONS ABOUT EXTERNALITIES

1. **Theoretical:** What is the best way to correct externalities and move closer to the social optimum?
2. **Empirical:** How to measure the size of externalities?

CORRECTING EXTERNALITIES: AN EXAMPLE I

- Consider a two-good model where firms produce cars x using numeraire y . Producing x cars entails use of $c(x)$ units of the numeraire and generates pollution and congestion.
- We denote by $B(X)$ the pollution and congestion generated by all cars. Note that X is the aggregate number of cars in the economy something that neither individual producers nor individual consumers think they can affect.
- Households suffer pollution and congestion with marginal damage h .
- Consumers have wealth Z and quasilinear utility

$$u(x) + y - hB(X)$$

- Social welfare: $W = u(X) + Z - c(X) - h B(X)$ (note how welfare takes into account all cars)

CORRECTING EXTERNALITIES: AN EXAMPLE II

- Competitive equilibrium: let p denote price of cars. Firms maximize

$$\max_x p x - c(x)$$

- Consumers maximize utility taking pollution as fixed (free rider problem):

$$\max_x u(x) + Z - p x \quad \text{They cannot do anything about } B(X)$$

- Demand satisfies (note that we use aggregate X)

$$u'(X^D) = p$$

- Supply satisfies (note that we use aggregate X)

$$c'(X^S) = p$$

CORRECTING EXTERNALITIES: AN EXAMPLE III

- Hence in equilibrium, marginal private benefit equals marginal private cost: the standard optimality condition

$$u'(X^D) = c'(X^S)$$

- Problem: this solution is now not Pareto efficient.
 - Marginal damage of production:

$$MD = h$$

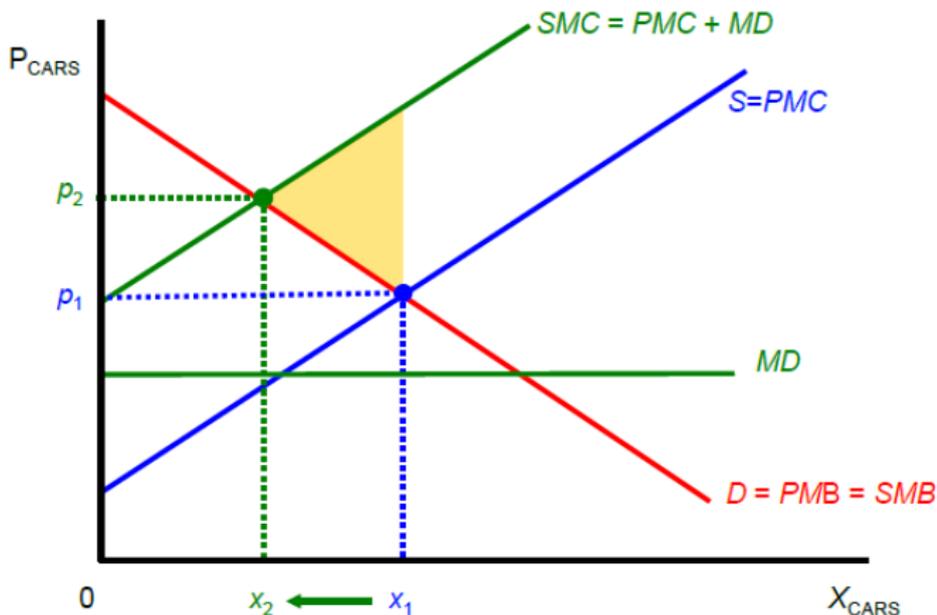
- Social Marginal cost of production:

$$c'(X) + h > c'(X)$$

2. Correcting Externalities

- Why is there inefficiency? deadweight loss triangle (Gruber figure 1)

Figure 1 Negative Production Externalities: Pollution



CORRECTING EXTERNALITIES: MATH ARGUMENT

- Can see this inefficiency formally using a perturbation argument: suppose I reduce production by dx . Then

$$dW = u'(x) dx - c'(x) dx - h \cdot dx = -h \cdot dx > 0 \text{ if } dx < 0$$

- Hence social welfare rises if production is reduced and First Welfare Theorem fails.
- Analogous result for consumption externalities. (see figure 2)
 - Social optimum: X^* such that

$$\textit{Marginal Social Cost} = \textit{Marginal Social Benefit}$$

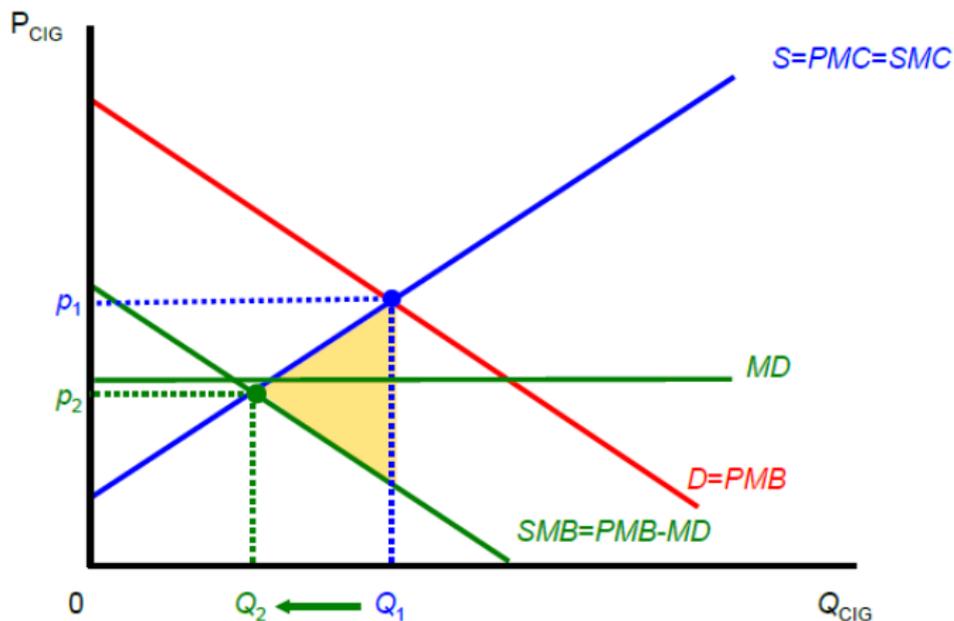
- Market outcome X^M such that

$$\textit{Marginal Private Cost} = \textit{Marginal Private Benefit}$$

2. Correcting Externalities

- DWL and Consumption externalities(Gruber figure 2)

Figure 2 Negative Consumption Externalities: Cigarettes



KEY LESSONS IN A MODEL WITH EXTERNALITIES

- Private markets do not produce Pareto Efficient outcome because firms do not take into account social cost of pollution.
- Zero pollution is not (necessarily) desirable.
- Need to know the shapes of MB, MPC, MD to implement X^* .
- Measurement of MD is especially problematic because you cannot use revealed preference (no market that is why there is an externality).

1. Establish property rights and create markets for pollution (Coasian solution):
2. Emission taxes or Pigouvian corrective taxation:
3. Regulation: Command and Control
4. Permits (cap-and-trade).

1. ESTABLISH PROPERTY RIGHTS AND CREATE MARKETS FOR POLLUTION

COASIAN SOLUTION

- Externalities emerge because property rights are not well defined.
- Suppose that the firm pollutes a river. If the river is owned by the consumer, then the firm has no right to pollute the river without the agreement of the consumer.
- In a competitive market, consumer would charge $\$h$ for every unit of pollution emitted \rightarrow firm's marginal cost of production becomes $c'(x) + h$. This would restore first-best.
- General point: Creating a market for buying the right to pollute would lead to the Pareto efficient outcome.

- Note that it does not matter who is assigned the property rights for the Coasian solution.
 - Suppose firm owned the river. Then it would offer to sell the consumer rights access to a less polluted river, and in equilibrium the price for a river that is 1 unit less polluted would be $\$h$ higher. Thus the firm's effective opportunity cost of producing a car would be $c'(x) + h$ and efficiency is restored.
 - Assignment of property rights affects distribution but not efficiency
→ all that matters is that we need to create markets.

THREE PROBLEMS WITH COASIAN SOLUTION

1. Cost of bargaining neglected. Cost of bargaining very large when the number of agents involved is large.
 - Example: air pollution, millions of people suffer from atmospheric pollution.
 - Need an association to come in to bargain in the name of agents who are affected. This “association” is the role of the government.
2. Asymmetric information problem: Resource owners need to be able to identify source of damage. For atmospheric pollution, difficult to identify precisely what harm each polluter is doing. Competitive equilibrium can break down if information is not perfect.
3. There is a residual monopoly problem. **All** the owners of property rights have to be bought off. Incentive to hold off and be last to command a huge prize that extracts all the rents.

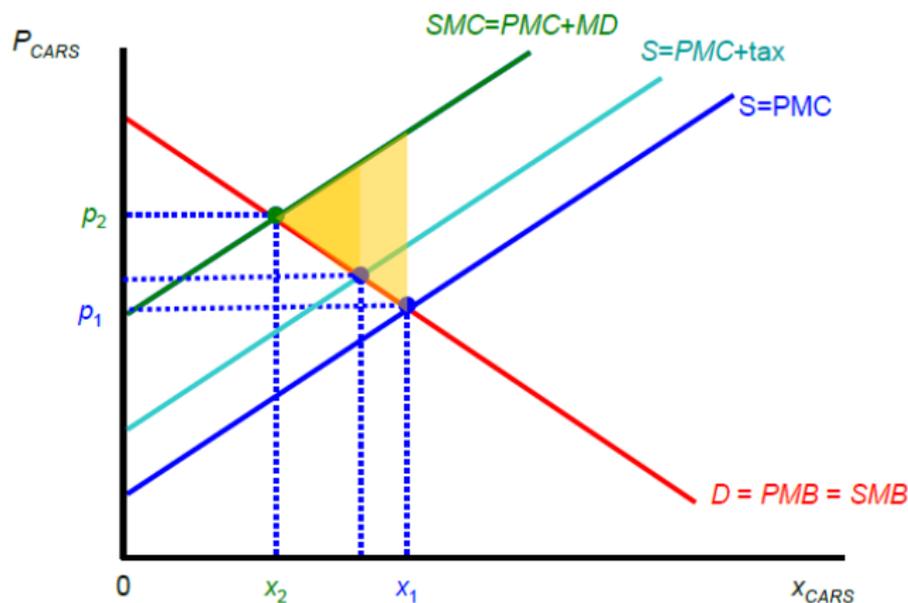
2. EMISSION TAXES OR PIGOUVIAN CORRECTIVE TAXATION

- Impose a tax equal to the marginal damage inflicted at the optimum X^* . Effective *Marginal Private Cost* shifts up, and the new market equilibrium is at X^* . (see figure 3)
- The optimal Pigouvian tax of $t = d$ restores Pareto efficiency and maximizes welfare in our simple model.
- General principle of optimal taxation in this context: set tax equal to wedge between marginal social cost of production and marginal private cost to restore production efficiency (i.e. set tax equal to marginal damage).

2. Correcting Externalities: Remedies for Externalities

2. Emission taxes (Pigouvian corrective taxation): Optimal pigouvian tax sets $t = MD(Q^*)$

Figure 3 Pigouvian Tax



- Need to know the *Marginal Damage*, (MD) function to set-up the optimal tax. Hard if MD not constant.
- Think of gasoline tax and car pollution: True that cars produce pollution, but difficult to measure the marginal damage done by cars. What is the optimal Pigouvian tax: European level or US level?

3 REGULATION: COMMAND AND CONTROL

- Each polluter has to cut pollution down to a certain level or use only certain types of production processes or else face legal sanctions.
- In the simple model sketched above, Pigouvian tax and regulation produce exactly the same outcome.
- But in general it does not do the job. How can the government command how much water or electricity people use?

ADVANTAGES AND OF REGULATION

- Advantages of regulation:

1. Easier to enforce/administer.
2. Useful to quickly reduce pollution levels if you want to meet a certain salient target. Can be sure to meet a certain target, easier to enforce politically, rather than agree on some taxes that may or may not achieve much of a pollution reduction.

- Disadvantage of regulation:

Dynamics Discourages innovation: no monetary incentives to discover new technologies to reduce pollution further. With a tax, there is such an incentive.

Heterogeneity Inefficient allocation when there is heterogeneity in costs of pollution abatement across firms

4. PERMITS (CAP-AND-TRADE)

- Problems raised above can be addressed using a auction-based permit system.
- Cap total amount of pollution and allow firms to sort out between themselves who pollutes more and less using tradeable permits
- In equilibrium, firms with highest marginal costs of reducing pollution will end up buying the most permits. Firms that can easily reduce pollution will do so.
- If total number of permits is set to achieve the social optimum, both allocative and productive efficiency will be achieved.
- Also have dynamic incentives to innovate because each firm is bearing a marginal cost of pollution.
- Note that price mechanism (Pigouvian tax) also has these desirable properties with heterogeneity and dynamics. So how to choose between price mechanism (tax) and permit (quantity) mechanism? Weitzman (REStud 1974).

SO PRICE OR PERMIT [WEITZMAN (REStUD 1974)]

- key insight: When there is uncertainty about Marginal Benefits and/or Marginal Costs, price and quantity policies may no longer be equivalent.
- Depends on the relative steepness of those curves

WHAT ARE CORRECTIVE TAXES?

Corrective (or “Pigouvian”) taxes can be used to correct for the presence of externalities or “internalities” in a market:

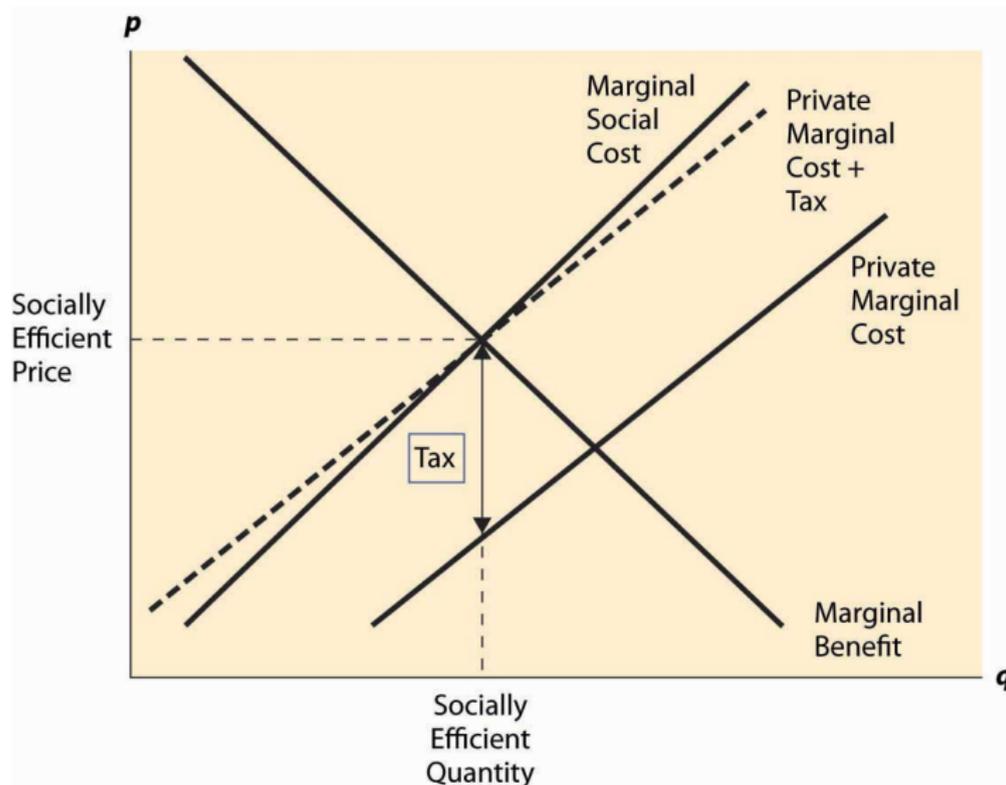
- externality: costs imposed on others
- internality: costs imposed on the individual themselves that the government wants to reduce.

Corrective taxes are commonly implemented as “excise taxes”:

- e.g. on motor fuels, tobacco, and alcohol
- taxes on these goods comprise 7.2% of total tax receipts (UK)

Taxes should be set based on the marginal social harm associated with consumption.

Corrective tax = marginal externality



A MORE FORMAL LOOK INTO PIGOUVIAN TAXATION: A SIMPLE MODEL

Consider a social planner who maximises the sum of consumer surplus, tax revenue minus the externality cost:

$$\max W(\tau) = \underbrace{\left[\frac{V(\tau)}{\alpha} \right]}_{\text{consumer surplus}} + \underbrace{R(\tau)}_{\text{tax revenue}} - \underbrace{\phi(Q(\tau))}_{\text{external costs}}$$

- τ is the tax policy
- α : marginal utility of income
- $V(\tau)$: indirect utility from consumption
- $Q(\tau)$: quantity consumed of externality generating good
- $\phi(Q(\tau))$: externality generated

What is the optimal τ in this case?

HOW TO CHOOSE PIGOUVIAN TAXES

Differentiating $W(t)$ with respect to τ and additional manipulations (do not worry about them) yields the Pigouvian tax result:

$$\tau^* = \phi'[Q(\tau^*)]$$

i.e. the optimal tax equals the marginal externality of consumption at that tax rate.

This looks very simple, BUT, in reality there are complicating factors:

1. variation across consumers
2. measuring the externality
3. restricted instruments available to government

THREE PRINCIPLES OF CORRECTIVE TAXATION

1. Tax should target the externality generating behaviour as directly as possible
2. Governments should not hesitate to set corrective taxes above the revenue maximising rate if the targeted activity is particularly harmful.
3. The regressivity of a corrective tax is not a sufficiently good reason for not implementing it. (Gambling, Gas, Alcohol)

AN EXAMPLE: THE EXTERNALITIES OF ALCOHOL CONSUMPTION

Significant health costs:

- 5.9% global deaths, and 5.1% of the global burden of disease and injury is attributable to alcohol (WHO, 2014)
- Roughly 70% of liver cirrhosis is attributable to alcohol
- Linked to violence and crime:
 - Almost half of all violent crime is alcohol related
 - Around 1/3 domestic violence occurs when the perpetrator is under the influence of alcohol
 - The alcohol attributable fraction of road traffic deaths is 16.6% for men and 6.7% for women

VARIATION IN THE MARGINAL EXTERNALITY

- There is a large amount of evidence that suggests that externalities are convex in alcohol consumption
 - i.e. the more you drink the greater the external cost associated with one more drink
- Threshold effect with some diseases: at low levels of alcohol consumption the risk is not elevated, but this risk increases sharply above a certain point.
- Higher levels of alcohol consumption create an exponential risk of accidents:
 - Odds of injury from 8 pints almost 18 times greater than the odds of injury from 1 pint

WHAT IS THE OPTIMAL ETHANOL TAX IN THIS CASE?

- Recall that the optimal Pigouvian tax, that achieves the first best, is to set the tax equal to the marginal externality:

$$\tau^* = \phi'[Q(t)]$$

But if the marginal externality varies across consumers (indexed i) and we have to set a single tax rate for all consumers, we can no longer achieve the first best:

- some consumers will face a tax rate that's too high, and some too low Diamond (1973) showed that the second best ethanol tax in this case is to set the tax equal to a weighted average of the marginal externalities:

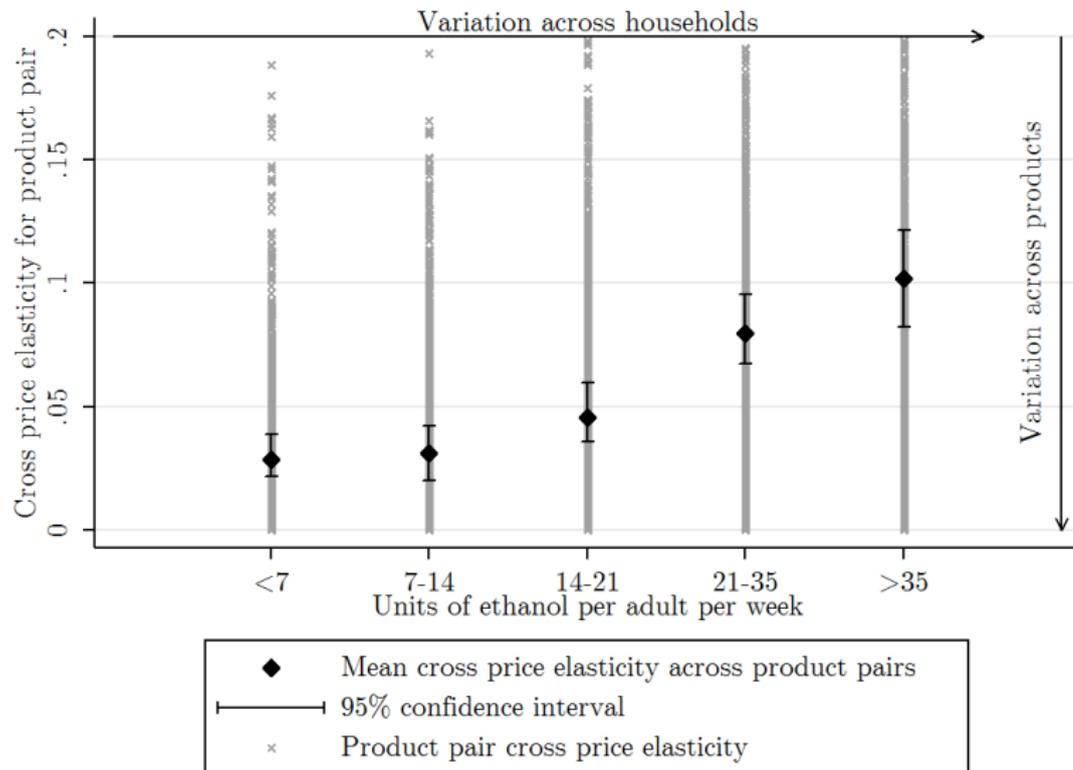
$$\tau^* = \sum_i \phi'_i[Q(\tau^*)] w_i$$

- But can we improve upon this?

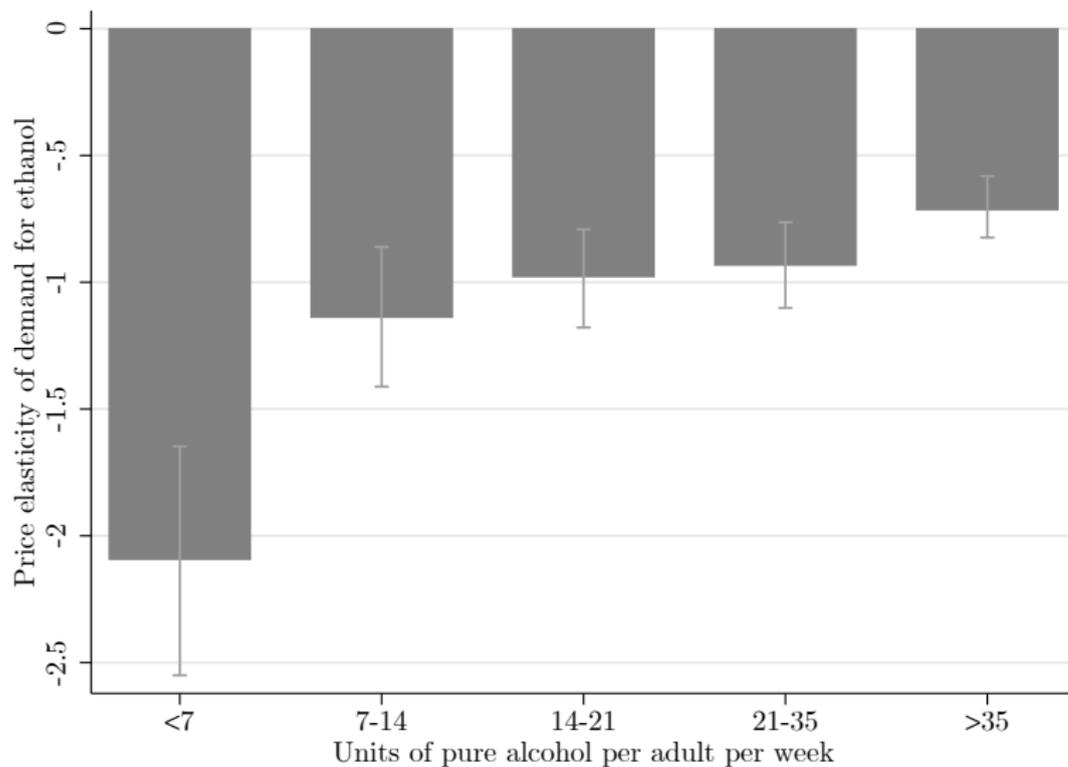
DIFFERENTIATING TAX RATES ACROSS PRODUCTS

- Although ethanol (pure alcohol) consumption generates the externality, ethanol content is only one product characteristic that consumers value:
 - consumers have preferences over whether a product is beer, or a spirit, and if beer, whether it is lager or stout
 - these give rise to demands for distinct alcohol products
- Correlation between ethanol demand and demand for distinct alcohol products provides the opportunity to design feasible corrective taxes that can improve on the Diamond prescription:
 - higher tax rates on products preferred by high marginal externality individuals
 - if high marginal externality individuals have high cross price effects, this acts to lower optimal tax rates

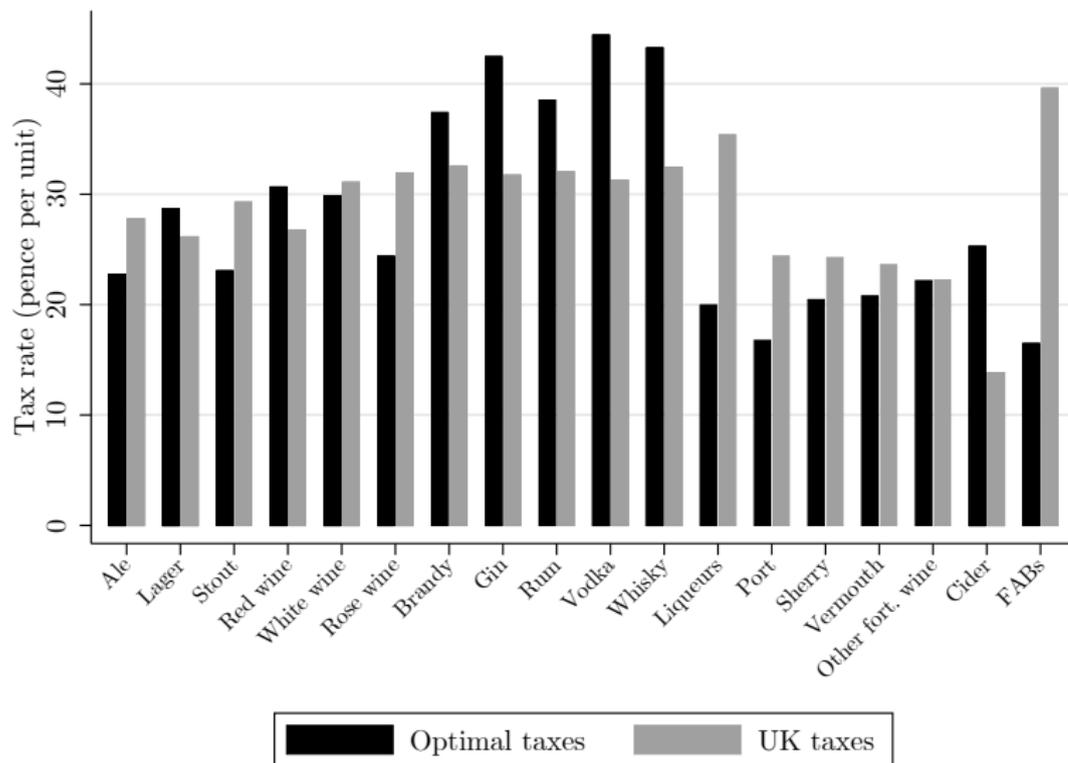
Cross price elasticities and marginal externalities



Price elasticity of demand for ethanol



Optimal alcohol taxes



The welfare impact of reforming alcohol taxation

<i>£ billion per year</i>	(1) External cost	(2) Tax revenue	(3) Change in consumer surplus	(3) + (4) - (2) Change in consumer welfare
UK taxes	7.25	7.16	-	-
Ethanol tax	-2.00	0.31	-1.85	0.46
<i>% difference</i>	-27.6	4.3	-	-
Type taxes	-2.15	-0.48	-0.63	1.05
<i>% difference</i>	-29.7	-6.7	-	-
Consumer specific taxes	-1.38	0.57	0.19	2.14
<i>% difference</i>	-19.0	8.0	-	-

CONCLUSION

- Corrective taxes are effective instruments for correcting for the presence of externalities or internalities in a market.
- Implementing them involves overcoming complicating factors:
 - variation in the marginal externality of consumption across individuals
 - often poor measurement of the external costs
 - legislative barriers to designing the taxes that would be optimal
- But we can use economic theory and empirical analysis to tackle these issues and help guide better corrective tax design.

The case for Taxing Sugar

A tax on sugar?

In the March 2016 Budget, the government introduced a tax on sugar-sweetened soft drinks.

1. What is the economic justification for a sugar tax?
2. Is the proposed tax structure sensible?

Rationale for policies to curb sugar consumption

Health risks:

- increases risk of consuming too many calories, hence obesity
- obesity increases risk of heart disease, type 2 diabetes, strokes
- linked to tooth decay in children

Many of the health costs are borne by the individual, but may also generate external costs borne by society (e.g. public health costs).

Also likely that the full costs of sugar consumption are not taken into account by the individual at the point of consumption.

- especially true for children
- evidence of self-control problems

In order to correct for these excess costs, we need to set the tax equal to the marginal externality or internality.

But the marginal externality (or internality) is likely to vary across people and consumption occasions:

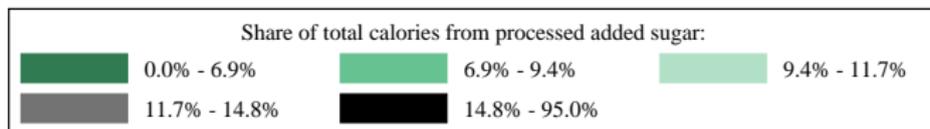
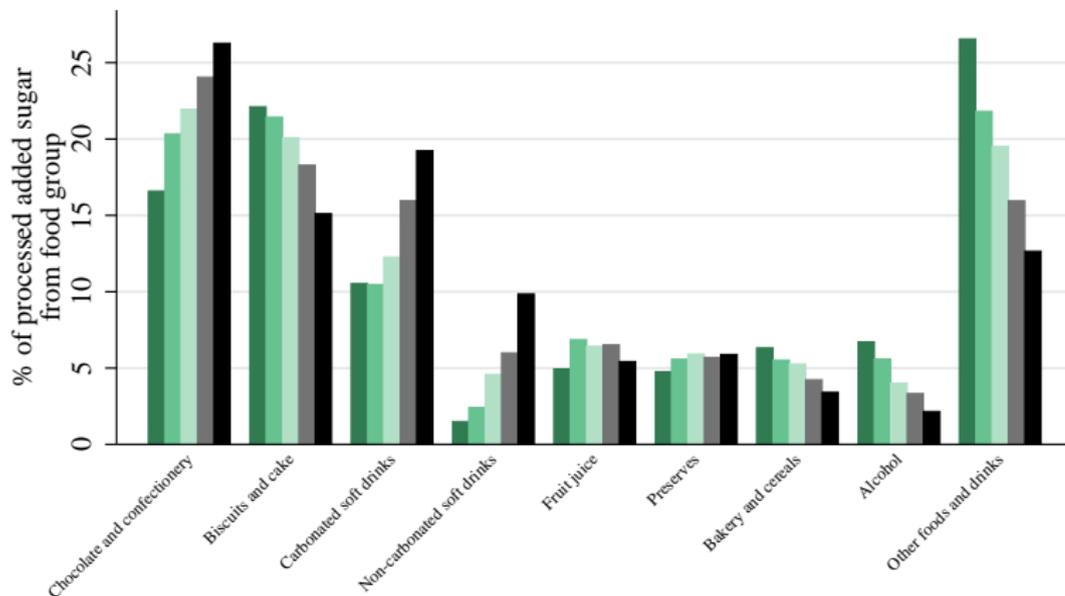
- compare an obese person and a competitive athlete eating the same chocolate bar

This means that there is a trade-off between reducing the consumption of people who consume more than is ideal and raising the prices faced by individuals whose behaviour does not generate external costs:

- suggests that we should target products disproportionately bought by those about whom we're particularly concerned

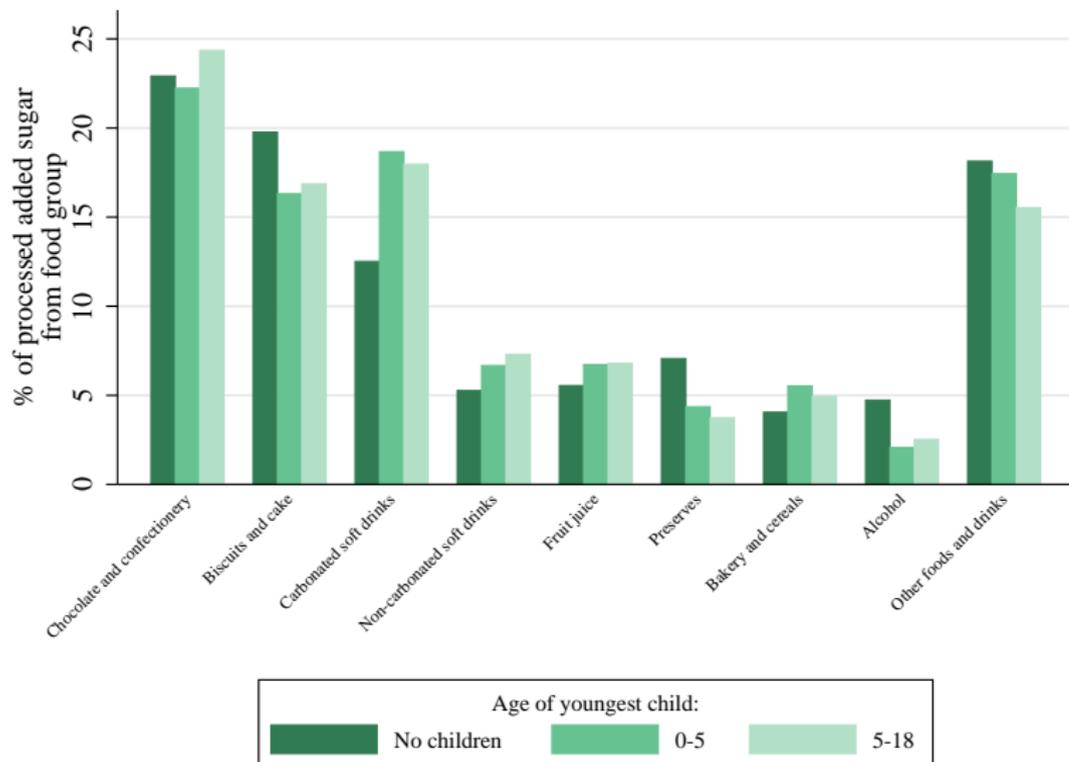
Sources of dietary sugar

By total added sugar purchases



Sources of dietary sugar

By age of youngest child



Taxing sugary soft drinks

Households who consume too much sugar, and households with children, get a disproportionate amount of sugar from soft drinks

- suggests that a soft drinks tax might be reasonably well targeted

But how will consumers respond to the price changes induced by a tax?

- if they switch to chocolate or confectionery then this could offset the reduction in sugar from soft drinks

Illustrative example

	Scenario:			
	(1)	(2)	(3)	(4)
Taste for sugar				
For households that buy:				
high amount of added sugar	Weak	Moderate	Strong	Strong
low amount of added sugar	Weak	Moderate	Strong	Moderate
% change in total sugar				
For households that buy:				
high amount of added sugar	-3.0%	-2.4%	-1.6%	-1.6%
low amount of added sugar	-3.0%	-2.4%	-1.6%	-2.4%
Average	-3.0%	-2.4%	-1.6%	-2.1%

Notes: We assume that: a tax on sugary drinks (carbonated, non-carbonated and fruit juice) would lead to a price increase of 15%, the own-price elasticity of sugary drinks is -1.0, the cross price elasticities of chocolate and confectionery with respect to the change in the price of sugary drinks is 0 in scenario (1), 0.2 in scenario (2), 0.5 in scenario (3) and 0.5 for high added sugar households and 0.2 for low added sugar households in scenario (4). We consider households that purchase less/more than 15% of their calories from added sugar as households that buy a high/low amount of sugar.

The 'Soft Drinks Levy'

Tax paid by producers and importers of soft drinks that contain added sugar implemented from April 2018 onwards

- excludes pure fruit juices and milk-based drinks

The tax will operate with a specific revenue target of £500 million for the second year of implementation (2019-20).

The OBR estimates that this implies levy rates of:

- main rate charge: 18p/litre for drinks with 5-8g of sugar per 100ml
- higher rate charge: 24p/litre for drinks with >8g sugar per 100ml

The tax is levied per litre of product, which means that tax per gram of sugar is lower for sugar products.

Incentives for reformulation

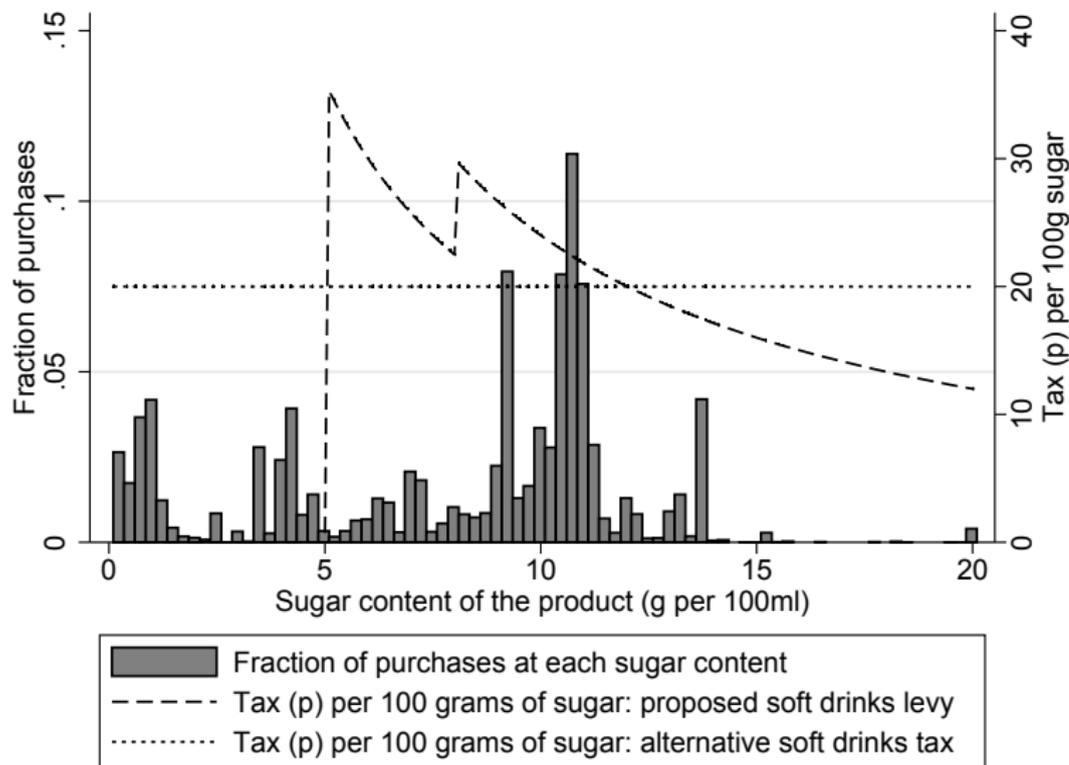
The declared intention of the levy is to encourage manufacturers to reformulate their products.

The proposed structure will only set limited incentives to reformulate:

- strong incentives to reformulate if the product is just above the 5g or 8g threshold
- for products further above the threshold, there are much weaker incentives for reformulation

If the tax were levied per gram of sugar, then there would be clearer incentives for all manufacturers to lower the sugar contents of their products.

The design of the proposed 'Soft Drinks Levy'



Someone could pay less tax and consume more sugar by choosing different products:

- 3l Coca Cola: 318 grams of sugar, 72p of tax
- 2l Sainsbury's Orange Energy Drink: 318 grams of sugar, 48p of tax