

Public Economics

Lecture 5: Taxation of commodities

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2012-2013, Spring semester

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- ① Introduction
- ② Tax incidence
- ③ Optimal commodity taxation

- 1 Introduction
- 2 Tax incidence
- 3 Optimal commodity taxation

- What happens when a tax is introduced or changed?
- Knowing about it, what tax system should we design?

- 1 Introduction
- 2 Tax incidence
 - Partial equilibrium incidence
 - Tax salience
 - General equilibrium incidence
- 3 Optimal commodity taxation

What is tax incidence?

- Tax incidence is the study of the effects of tax policies on prices and the distribution of welfare.
- Effects on prices, quantities, profits, utilities, inputs prices and quantities, capital returns, etc. . .
- Positive analysis as first step in policy evaluation before looking for the social welfare maximizing policy.
- Empirical analysis is important as theory is frequently inconclusive.
- Ideally, we want to know the effect of a tax change on utility levels of all agents.
- Realistically, we usually look at impact on prices or income of some agents.

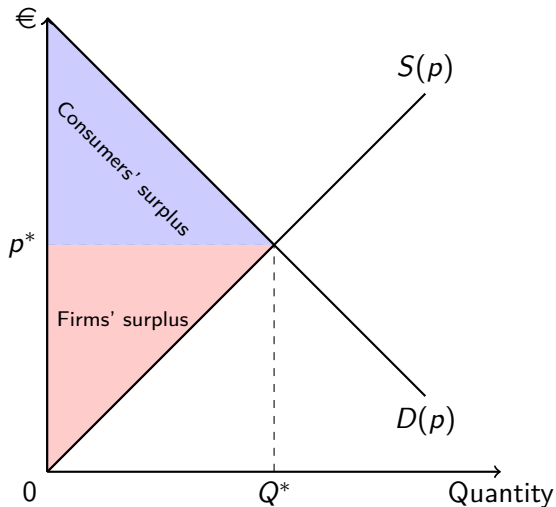
Partial equilibrium incidence

Kotlikoff, Laurence J. & Summers, Lawrence H., 1987. "Tax incidence," Handbook of Public Economics, in: A. J. Auerbach & M. Feldstein (ed.), Handbook of Public Economics, edition 1, volume 2, chapter 16, pages 1043-1092, Elsevier.

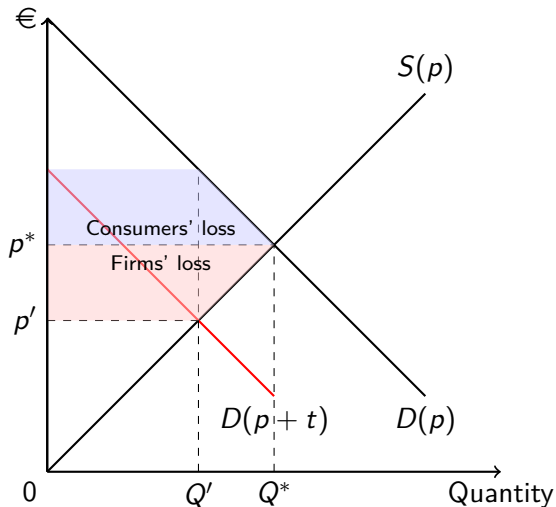
Key assumptions:

- Economy with only two goods: approximation of incidence in a multi-good model if:
 - The market being taxed is "small",
 - There are no close substitutes or complements in the utility function.
- Tax revenue is not spent on the taxed good: used to buy the untaxed one, or simply thrown away.
- Perfect competition.

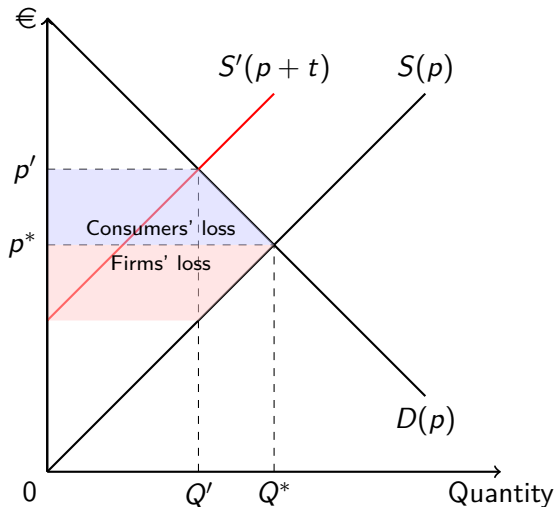
No tax



Unit tax levied on consumers



Unit tax levied on producers



Setup of the model

- Two goods: x and y .
- The government levies an excise tax on good x :
 - Excise tax: levied on a quantity, fixed in nominal terms;
 - Ad-valorem tax: fraction of price.
- Let p denote the pretax price of x and $q = p + t$ denote the tax inclusive price of good x .
- Good y is the untaxed numeraire.

- Representative consumer has wealth Z and utility $u(x, y)$.
- Facing price q , the consumer demands quantity $D(p)$ of good x as $q = p + t$.
- Let ε_D denote the price elasticity of demand:

$$\varepsilon_D = \frac{\partial D(p)/D(p)}{\partial p/q}.$$

- Firms are price-takers.
- Use $c(S)$ units of y to produce S units of good x , with $c'(S) > 0$ and $c''(S) \geq 0$.
- Firms choose supply S in order to maximize profit at pretax price p :

$$\max pS - c(S) \Rightarrow p = C'(S(p)).$$

- Let ε_S denote the price elasticity of supply:

$$\varepsilon_S = \frac{\partial S(p)/S(p)}{\partial p/p}.$$

Equilibrium

- Equilibrium condition:

$$S(p^*) = D(p^* + t),$$

implicitly defines $p^*(t)$.

- The objective is to characterize $\partial p/\partial t$ and $\partial q/\partial t$, the effects of a tax increase on unit revenue from firms and unit cost for consumers.

- Implicitly differentiate the equilibrium condition with respect to t and p :

$$\frac{\partial S}{\partial p} dp = \frac{\partial D}{\partial p} dp + \frac{\partial D}{\partial t} dt.$$

- This yields:

$$\frac{dp}{dt} = \frac{\partial D}{\partial p} \frac{1}{\frac{\partial S}{\partial p} - \frac{\partial D}{\partial p}},$$

or:

$$\frac{dp}{dt} = \frac{\varepsilon_D}{\varepsilon_S - \varepsilon_D},$$

with $-1 < \frac{dp}{dt} < 0$.

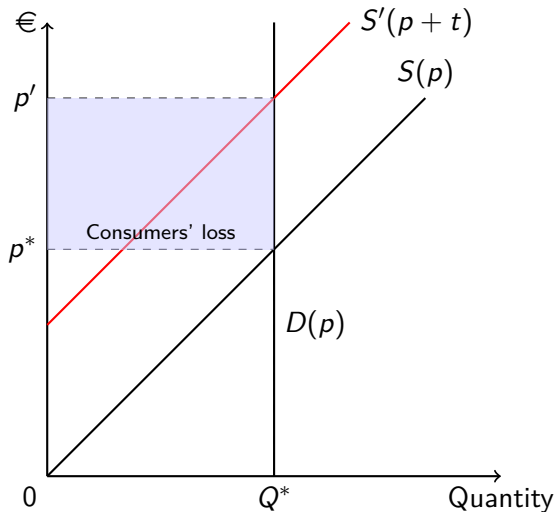
- The change in unit cost for consumers is :

$$\frac{dq}{dt} = 1 + \frac{dp}{dt} = \frac{\varepsilon_S}{\varepsilon_S - \varepsilon_D}.$$

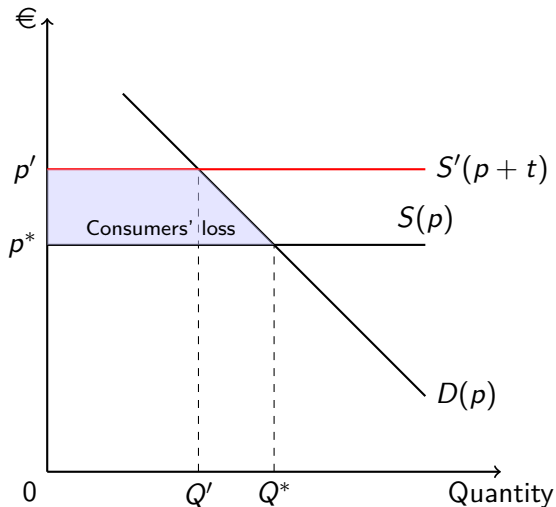
Who's bearing the burden of the tax ?

- Consumers bear the entire burden when:
 - $\varepsilon_D = 0$, i.e. the demand is inelastic (day-to-day demand for gas);
 - $\varepsilon_S = +\infty$, i.e. the supply is perfectly elastic (perfectly competitive industry).
- Producers bear the entire burden when:
 - $\varepsilon_S = 0$, i.e. the supply is inelastic (short term fixed supply, e.g. housing);
 - $\varepsilon_D = -\infty$, the demand is perfectly elastic (there exists a close substitute and demand shifts to it when price increases).

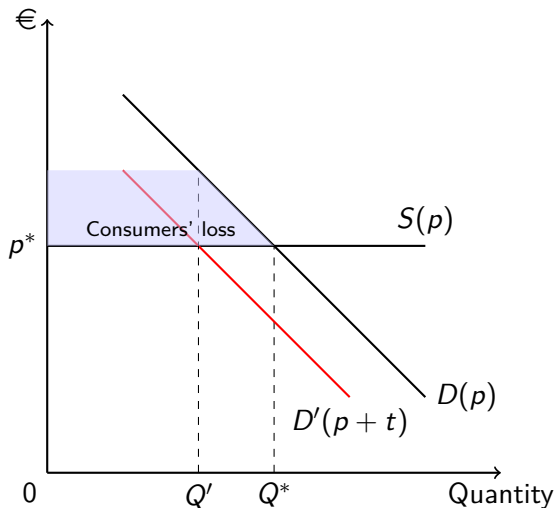
Perfectly inelastic demand



Perfectly elastic supply (1)



Perfectly elastic supply (2)



Key findings

- Equilibrium is independent of who nominally pays the tax.
- Less elastic side of the market bears relatively more the taxation burden.

Empirical evidence

Doyle Jr., Joseph J. & Samphantharak, Krislert, 2008. "\$2.00 Gas! Studying the effects of a gas tax moratorium," *Journal of Public Economics*, Elsevier, vol. 92(3-4), pages 869-884, April.

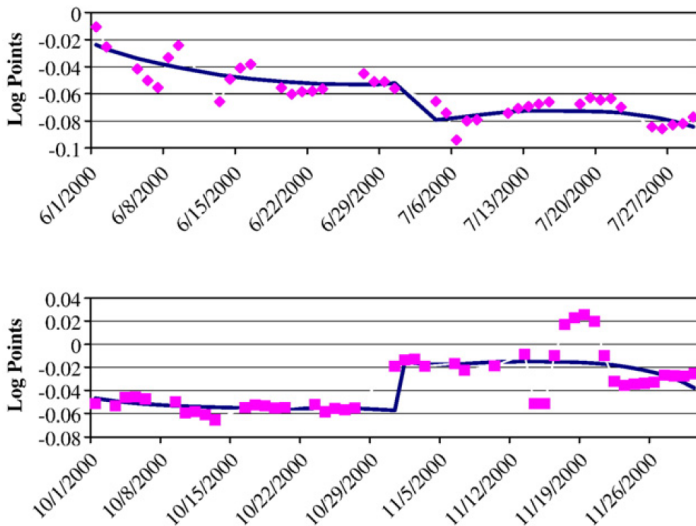
- Question: Who bears the burden of the gas tax?
- Context: Gas prices spike above \$2 in 2000, near election.
- Political desire to provide tax relief.
- Temporary reform:
 - 5% sales tax on gas was suspended between July 1st and October 30th in Indiana and Illinois.

- Identification relies on difference in differences: compares treated states to neighboring states.
- Observations at the station level (s).
- Baseline econometric specification:

$$\text{Price}_{st} = \alpha_1 (\text{Illinois or Indiana})_s + \alpha_2 (\text{Reform period})_t + \alpha_3 (\text{Illinois or Indiana})_s \times (\text{Reform period})_t + \dots$$

└ Tax incidence

└ Partial equilibrium incidence



Difference in (log) prices against time.

Source: Doyle and Samphantharak (2008)

Main findings:

- 70% of tax reductions is passed to consumers in the form of lower prices.
- 80% to 100% of tax reinstatements is passed to consumers on the form of higher prices.

Tax salience

- Central assumption of many models (including the previous analysis): Taxes are equivalent to prices, that is:

$$\frac{dX}{dt} = \frac{dX}{dp}.$$

- In practice, taxes may have different effects on demand whether people are aware or not.
- Tax salience:

Tax a is more salient than tax b if calculating the gross-of-tax price under a requires less computation than calculating gross-of-tax price under b.

Raj Chetty & Adam Looney & Kory Kroft, 2009. "Salience and Taxation: Theory and Evidence," *American Economic Review*, American Economic Association, vol. 99(4), pages 1145-77, September.

- Test whether salience (visibility of tax-inclusive price) affects behavioral responses to commodity taxation. In other terms, does the effect of a tax on demand depend on whether it is included in the posted price?
- Field experiment: change salience of tax implemented at a supermarket belonging to a major grocery chain.
- Data: weekly price and quantity sold by product.

└ Tax incidence

└ Tax salience



Source: Chetty, Looney and Kroft (2009)

Experimental difference in differences:

- Treatment group:
Cosmetics, deodorants and hair care accessories in one large store in northern California during three weeks in 2006.
- Control groups:
 - Other products from the same store and in same category (e.g. toothpaste, skin care, shave);
 - Same products in two nearby stores.

Tax incidence

Tax salience

TABLE 3—EFFECT OF POSTING TAX-INCLUSIVE PRICES: DDD ANALYSIS OF MEAN QUANTITY SOLD

Period	Control categories	Treated categories	Difference
<i>Panel A. Treatment store</i>			
Baseline (2005:1–2006:6)	26.48 (0.22) [5,510]	25.17 (0.37) [754]	-1.31 (0.43) [6,264]
Experiment (2006:8–2006:10)	27.32 (0.87) [285]	23.87 (1.02) [39]	-3.45 (0.64) [324]
Difference over time	0.84 (0.75) [5,795]	-1.30 (0.92) [793]	$DD_{TS} = -2.14$ (0.68) [6,588]
<i>Panel B. Control stores</i>			
Baseline (2005:1–2006:6)	30.57 (0.24) [11,020]	27.94 (0.30) [1,508]	-2.63 (0.32) [12,528]
Experiment (2006:8–2006:10)	30.76 (0.72) [570]	28.19 (1.06) [78]	-2.57 (1.09) [648]
Difference over time	0.19 (0.64) [11,590]	0.25 (0.92) [1,586]	$DD_{CS} = 0.06$ (0.95) [13,176]
<i>DDD Estimate</i>			-2.20 (0.59) [19,764]

Notes: Each cell shows mean quantity sold per category per week, for various subsets of the sample. Standard errors (clustered by week) in parentheses, number of observations in square brackets. Experimental period spans week 8 in 2006 to week 10 in 2006. Baseline period spans week 1 in 2005 to week 6 in 2006. Lower panel reflects averages across the two control stores.

- Key finding: salience matters.
- Additional findings (not shown here): price changes and tax changes have different effects.
- All in all, the change in demand is larger the more salient the tax.
- Conclusive findings: taxes on producers have greater incidence on producers than non-salient taxes levied on consumers.

General equilibrium incidence

- Trace incidence back to original owners of production factors.
- Benchmark static analysis by Harberger (1962).

Arnold C. Harberger, 1962. "The Incidence of the Corporation Income Tax," Journal of Political Economy, University of Chicago Press, vol. 70, pages 215.

- Short-run analysis of a closed economy: fixed total supply of labor L and capital K .
- Full employment of L and K .
- Perfect competition.
- Only two production sectors.
- Yet, heavy analytical derivation.
- Hard to predict anything precisely.

- 1 Introduction
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 - Ramsey rule
 - Production efficiency

- Goal is to maximize social welfare subject to revenue constraint.
- First best:
 - Suppose we have perfect information, complete markets, perfect competition, and lump sum taxes feasible (at no cost).
 - Second welfare theorem implies that any Pareto-efficient allocation can be achieved as a competitive equilibrium with appropriate lump-sum transfers (or taxes).
 - Economic policy problem reduces to the computation of the lump-sum taxes necessary to reach the desired equilibrium. No equity-efficiency trade-off.
- Problems:
 - No way to make people reveal their characteristics at no cost: to avoid paying a high lump-sum, a skilled person would pretend to be unskilled.
 - Government has to set (distortionary) taxes as a function of economic outcomes: income, property, consumption of goods.

- End up with second best inefficient taxation: its impossible to redistribute or raise revenue for public good provision without generating efficiency costs.
- Here, discuss optimal commodity taxation.
- Two main (qualitative) results in optimal commodity taxation theory:
 - Ramsey rule;
 - Diamond and Mirrlees production efficiency.

Ramsey rule

- Ramsey (1927) tax problem:
the government set taxes on uses of income in order to raise revenue and minimize social loss; which goods should be taxed?
- Key assumptions:
 - Lump-sum taxation is not available.
 - Leisure cannot be taxed.
 - Production prices are fixed and normalized to one:

$$p_i = 1 \text{ and } q_i = 1 + \tau_i.$$

Setup of the model

- N goods indexed by $i = 1, \dots, N$.
- Mass one of individuals who maximize utility

$$u(x_1, \dots, x_N, l),$$

subject to budget constraint

$$\sum_{i=1}^N q_i x_i \leq wl + Z,$$

where q_i is consumption price of good i , wl is labor income and Z is exogenous wealth.

Consumer's problem

- Using Lagrangian multiplier α , first order conditions can be written as:

$$\frac{\partial u}{\partial x_i} = \alpha q_i \forall i, \text{ and } \frac{\partial u}{\partial l} = \alpha w.$$

- These conditions yield implicit demand functions

$$x_i(q, Z),$$

and indirect utility function

$$V(q, Z),$$

where $q = (w, q_1, \dots, q_N)$.

Government's problem

- Given consumer's behavior, the government chooses taxes in order to maximize $V(q, Z)$, subject to revenue requirement

$$\sum_{i=1}^N \tau_i x_i(q, Z) \geq E$$

- Lagrange expression for the government can be written as:

$$\mathbb{L} = V(q, Z) + \lambda \left(\sum_{i=1}^N \tau_i x_i(q, Z) - E \right).$$

- Remember that for all i , $q_i = 1 + \tau_i$, such that to choose τ_i is identical to choose q_i .

- First order condition for all i :

$$\frac{\partial \mathbb{L}}{\partial q_i} = \underbrace{\frac{\partial V}{\partial q_i}}_{\text{Private welfare loss}} + \lambda \underbrace{x_i}_{\text{Mechanical effect}} + \lambda \underbrace{\sum_{j=1}^N \tau_j \frac{\partial x_j}{\partial q_i}}_{\text{Behavioral effect}} .$$

- Using Roy's identity $\left(\frac{\partial V}{\partial q_i} = -\alpha x_i\right)$, we get:

$$(\lambda - \alpha) x_i + \lambda \sum_{j=1}^N \tau_j \frac{\partial x_j}{\partial q_i} = 0.$$

- Optimal tax rates satisfy a system of N equations and N unknowns of the form:

$$\sum_{j=1}^N \tau_j \frac{\partial x_j}{\partial q_i} = -\frac{x_i}{\lambda} (\lambda - \alpha).$$

- Hard to interpret.

- Let us define

$$\theta = \lambda - \alpha - \lambda \frac{\partial \sum_{j=1}^N \tau_j x_j}{\partial Z}.$$

- θ measures the value for the government of introducing 1€ lump-sum tax:
 - Direct value for the government is λ ;
 - Private loss for individuals is α ;
 - Loss in tax revenue due to the behavioral response is the remaining term.

- Remember Slutsky equation :

$$\frac{\partial x_j}{\partial q_i} = \frac{\partial h_j}{\partial q_i} - x_i \frac{\partial x_j}{\partial Z},$$

where $h_j(\cdot)$ is Hicksian demand function for good j .

- After substituting and rearranging terms, we get a nice Ramsey rule:

$$\frac{1}{x_i} \sum_{j=1}^N \tau_j \frac{\partial h_i}{\partial q_j} = -\frac{\theta}{\lambda}.$$

- Which means that the optimal tax system should be such that the compensated demand for each good is reduced in the same proportion relative to the no-tax situation.
- That is, one should limit the distortion in terms of quantities rather than prices.
- Should tax heavier goods whose demand is less responsive to price changes.

Limitations of Ramsey rule

- Redistributive motives are not taken into account.
- Necessities are more inelastic than luxuries.
- Optimal Ramsey tax system is likely to be regressive.
- Diamond (1975) extends Ramsey model to take redistributive motives into account.

Diamond, P. A., 1975. "A many-person Ramsey tax rule," *Journal of Public Economics*, Elsevier, vol. 4(4), pages 335-342, November.

- Ramsey model where individuals differ in endowments and where the government seeks to maximize the sum of individual utilities.
- Optimal tax is still inversely proportional to the elasticity.
- But tax rate for goods consumed by the poorest is shifted down, whereas tax rate for goods consumed by the rich is shifted up.

Production efficiency

- Previous analysis ignored production by assuming that producer prices are fixed.

Diamond, Peter A & Mirrlees, James A, 1971. "Optimal Taxation and Public Production I: Production Efficiency" *American Economic Review*, American Economic Association, vol. 61(1), pages 8-27, March.

Diamond, Peter A & Mirrlees, James A, 1971. "Optimal Taxation and Public Production II: Tax Rules," *American Economic Review*, American Economic Association, vol. 61(3), pages 261-78, June.

- Relax this assumption and model production.
- Derive optimal tax policy to achieve production efficiency.

Setup of the model

- Many consumers, indexed by $h = 1, \dots, H$.
- Many goods, indexed by $i = 1, \dots, N$.
- Production prices are not constant. The production possibilities of the economy are represented by a production set.
- Key assumption: firms' profits do not enter the social welfare function (fully taxed profits or production functions with constant return to scale).

- The government chooses the vector $q = p + \tau$ in order to maximize

$$\mathbb{W} \left(V^1(q), \dots, V^H(q) \right) \text{ s.t. } \sum_{i=1}^N \tau_i X_i(q) \geq E,$$

where X_i is the sum of individual demands for good i given after tax prices q .

- The constraint can be replaced by

$$X(q) = \sum_{h=1}^H x^h(q) \in Y,$$

where Y is the production set which takes into account the revenue requirement E of the government.

Results and consequences

Results:

- Production efficiency result: at the optimum level of taxes q^* , the allocation $X(q^*)$ is on the boundary of Y .
- Optimal tax system *à la* Diamond (1975).

Consequences:

- Public sector should be efficient:
 - Should face the same prices as the private sector;
 - Should choose production with the unique goal of maximizing profits, not generating government revenues.
- Intermediate goods (neither direct inputs, nor outputs consumed by individuals) should not be taxed:
 - Taxing transactions between firms would distort (aggregate) production and prevent production efficiency.

Comments:

- Results rely on two key assumptions:
 - Government needs to be able to set a differentiated tax rate for each input or output;
 - Government needs to be able to tax away fully pure profits.
- These two assumption effectively separate the production's problem from the the consumption's one.
- These assumptions may be challenged.

End of lecture.

Lectures of this course are inspired from those taught by R. Chetty, G. Fields, N. Gravel, H. Hoynes, and E. Saez.