Public Economics Lectures
Tax and Expenditure Incidence

John Karl Scholz, borrowing from Raj Chetty and Gregory A. Bruich

University of Wisconsin – Madison
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Outline

1. Definition and Introduction
2. Partial Equilibrium Incidence
3. Partial Equilibrium Incidence with Salience Effects
4. Partial Equilibrium Incidence: Empirical Applications
5. General Equilibrium Incidence
6. Capitalization
7. Mandated Benefits
References on Tax Incidence

• Kotlikoff and Summers (1987) handbook chapter

• Atkinson and Stiglitz text chapters 6 and 7

• Chetty, Looney, and Kroft (2009)
Tax incidence is the study of the effects of tax policies on prices and the distribution of utilities.

What happens to market prices when a tax is introduced or changed?

- Increase tax on cigarettes by $1 per pack

Effect on price → distributional effects on smokers, profits of producers, shareholders, ...
Economic vs. Statutory Incidence

- Equivalent when prices are constant but **not** in general

- Consider the following argument:
  - Government should tax capital income b/c it is concentrated at the high end of the income distribution
  - Neglects general equilibrium price effects
    - Tax might be shifted onto workers
      - If capital taxes → less savings and capital flight, then capital stock may decline, driving return to capital up and wages down
    - Some argue that capital taxes are paid by workers and therefore increase income inequality (Hassett and Mathur, 2009)
Overview of Literature

- Tax incidence is an example of positive analysis
  - Typically the first step in policy evaluation
  - An input into thinking about policies that maximize social welfare
- Theory is informative about signs and comparative statics but is inconclusive about magnitudes
  - Incidence of cigarette tax: elasticity of demand w.r.t. price is crucial
  - Labor vs. capital taxation: mobility of labor, capital are critical
Overview of Literature

- Ideally, we would characterize the effect of a tax change on utility levels of all agents in the economy.

- Useful simplification in practice: aggregate economic agents into a few groups.

- Incidence analyzed at a number of levels:
  1. Producer vs. consumer (tax on cigarettes)
  2. Source of income (labor vs. capital)
  3. Income level (rich vs. poor)
  4. Region or country (local property taxes)
  5. Across generations (Social Security reform)
Partial Equilibrium Incidence: Key Assumptions

1. **Two good economy**
   - Only one relative price $\rightarrow$ partial and general equilibrium are same
   - Can be viewed as an approx. of incidence in a multi-good model if
     - the market being taxed is “small”
     - there are no close substitutes/complements in the utility function

2. **Tax revenue is not spent on the taxed good**
   - Tax revenue is used to buy untaxed good or thrown away

3. **Perfect competition among producers**
   - Relaxed in some studies of monopolistic or oligopolistic markets
Partial Equilibrium Model: Setup

- Two goods: $x$ and $y$

- Government levies an **excise** tax on good $x$
  - **Excise/Specific tax**: levied on a quantity (e.g. gallon, pack, ton)
  - **Ad-valorem tax**: fraction of prices (e.g. sales tax)

- Let $p$ denote the pretax price of $x$ and $q = p + t$ denote the tax inclusive price of $x$

- Good $y$, the numeraire, is untaxed
Partial Equilibrium Model: Demand

- Consumer has wealth $Z$ and has utility $u(x, y)$

- Let $\varepsilon_D = \frac{\partial D}{\partial p} \frac{p}{D(p)}$ denote the price elasticity of demand
  
  - **Elasticity**: % change in quantity when price changes by 1%

  - Widely used concept because elasticities are unit free
Partial Equilibrium Model: Supply

- Price-taking firms
- Use \( c(S) \) units of the numeraire \( y \) to produce \( S \) units of \( x \)
- Cost of production is increasing and convex:
  \[ c'(S) > 0 \text{ and } c''(S) \geq 0 \]
- Profit at pretax price \( p \) and level of supply \( S \) is \( pS - c(S) \)
- With perfect optimization, the supply function for good \( x \) is implicitly defined by the marginal condition \( p = c'(S(p)) \)
- Let \( \varepsilon_S = \frac{\partial S}{\partial p} \frac{p}{S(p)} \) denote the price elasticity of supply
Equilibrium condition

\[ Q = S(p) = D(p + t) \]

defines an equation \( p(t) \)

Goal: characterize \( \frac{dp}{dt} \), the effect of a tax increase on price

First consider some graphical examples to build intuition, then analytically derive formula
Tax Levied on Producers

Consumer Burden = $4.50
Supplier Burden = $3.00

Price
Quantity

$22.5 1250
$22.5
$19.5
$27.0
A
S+t
$7.50
$30.0

Tax Levied on Producers

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Tax & Expenditure Incidence
### Tax Levied on Consumers

<table>
<thead>
<tr>
<th>Price</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>$22.5</td>
<td>$22.5</td>
</tr>
<tr>
<td>$19.5</td>
<td></td>
</tr>
<tr>
<td>$7.50</td>
<td></td>
</tr>
<tr>
<td>$27.0</td>
<td></td>
</tr>
<tr>
<td>$15.0</td>
<td>$15.0</td>
</tr>
</tbody>
</table>

**A**

- **Consumer Burden = $4.50**
- **Supplier Burden = $3.00**

**D+C**

- **Public Economics Lectures**
- **Tax & Expenditure Incidence**

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**Graph: Tax Levied on Consumers**

- **Axes:** Price vs. Quantity
- **Points:**
  - **C:** Consumer Burden = $4.50
  - **D:** Supplier Burden = $3.00
  - **A:** Intersection of Demand and Supply
  - **B:** Quantity at $22.5
  - **D+t:** Shift of Demand due to Tax

**Price Levels:**
- $27.0
- $22.5
- $19.5
- $15.0

**Quantity Levels:**
- 1250
- 1500

**Arrow:**
- $7.50 rise in price due to tax

---

**Note:**
- The diagram illustrates the impact of a tax on the equilibrium price, shifting the demand curve and affecting the burden on consumers and suppliers.
Perfectly Inelastic Demand

Price

$27.0

$22.5

$7.50

Quantity

Consumer burden

Perfectly Inelastic Demand

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Perfectly Elastic Demand

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Price</th>
<th>Supplier burden</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$7.50</td>
<td>$22.5</td>
</tr>
<tr>
<td></td>
<td>$15.0</td>
<td>$15.0</td>
</tr>
</tbody>
</table>

Supplier burden

Price

$22.5

$15.0

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Tax & Expenditure Incidence
Implicitly differentiate equilibrium condition

\[ D(p + t) = S(p) \]

to obtain:

\[
\frac{dp}{dt} = \frac{\partial D}{\partial p} \left( \frac{1}{\frac{\partial S}{\partial p} - \frac{\partial D}{\partial p}} \right)
\]

\[ \Rightarrow \frac{dp}{dt} = \frac{\varepsilon_D}{\varepsilon_S - \varepsilon_D} \]

Incidence on consumers:

\[
\frac{dq}{dt} = 1 + \frac{dp}{dt} = \frac{\varepsilon_S}{\varepsilon_S - \varepsilon_D}
\]
Formula for Tax Incidence

1 – excess supply of E created by imposition of tax

2 – re-equilibration of market through producer price cut

\[ dp = E \left( \frac{\partial S}{\partial p} - \frac{\partial D}{\partial p} \right) \]

\[ \Rightarrow \frac{dp}{dt} = \frac{\partial D}{\partial p} \left( \frac{\partial S}{\partial p} - \frac{\partial D}{\partial p} \right) \]

\[ E = dt \times \frac{\partial D}{\partial p} \]
Central assumption of neoclassical model: taxes are equivalent to prices \( \frac{dx}{dt} = \frac{dx}{dp} \)

In practice, are people fully aware of marginal tax rates?

Chetty, Looney, and Kroft (2009) test this assumption and generalize theory to allow for salience effects

**Part 1:** Test whether “salience” (visibility of tax-inclusive price) affects behavioral responses to commodity taxation

- Does effect of a tax on demand depend on whether it is included in posted price?

**Part 2:** Develop formulas for incidence and efficiency costs of taxation that permit salience effects and other optimization errors
Economy with two goods, $x$ and $y$

Prices: Normalize the price of $y$ to 1 and let $p$ denote the (fixed) pretax price of $x$.

Taxes: $y$ untaxed, $x$ subject to an ad valorem sales tax $\tau$ (not included in posted price)

- Tax-inclusive price of $x$ is $q = p(1 + \tau)$.

Let demand for good $x$ be denoted by $x(p, \tau)$
If agents optimize fully, demand should only depend on the total tax-inclusive price: \( x(p, \tau) = x((1 + \tau)p, 0) \)

Full optimization implies price elasticity equals gross-of-tax elasticity:

\[
\varepsilon_{x,p} \equiv -\frac{\partial \log x}{\partial \log p} = \varepsilon_{x,1+\tau^S} \equiv -\frac{\partial \log x}{\partial \log (1 + \tau)}
\]

To test this hypothesis, log-linearize demand fn. \( x(p, \tau) \) to obtain estimating equation:

\[
\log x(p, \tau) = \alpha + \beta \log p + \theta \beta \log (1 + \tau)
\]

\( \theta \) measures degree to which agents under-react to the tax:

\[
\theta = \frac{\partial \log x}{\partial \log (1 + \tau)} \left/ \frac{\partial \log x}{\partial \log p} \right. = \frac{\varepsilon_{x,1+\tau}}{\varepsilon_{x,p}}
\]
Two strategies to estimate $\theta$:

1. **Manipulate tax salience**: make sales tax as visible as pre-tax price
   - Effect of intervention on demand:
     \[\nu = \log x((1 + \tau)p, 0) - \log x(p, \tau)\]
   - Compare to effect of equivalent price increase to estimate $\theta$:
     \[(1 - \theta) = -\frac{\nu}{\varepsilon_{x,p} \log(1 + \tau)}\]

2. **Manipulate tax rate**: compare $\varepsilon_{x,p}$ and $\varepsilon_{x,1+\tau}$
   \[\theta = \frac{\varepsilon_{x,1+\tau}}{\varepsilon_{x,p}}\]
Experiment manipulating salience of sales tax implemented at a supermarket that belongs to a major grocery chain

- 30% of products sold in store are subject to sales tax
- Posted tax-inclusive prices on shelf for subset of products subject to sales tax (7.375% in this city)

Data: Scanner data on price and weekly quantity sold by product
Source: Chetty, Looney, and Kroft (2009)
### TABLE 1
**Evaluation of Tags: Classroom Survey**

<table>
<thead>
<tr>
<th>Price Tags</th>
<th>Mean</th>
<th>Median</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Original Price Tags:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correct tax-inclusive price w/in $0.25</td>
<td>0.18</td>
<td>0.00</td>
<td>0.39</td>
</tr>
<tr>
<td><strong>Experimental Price Tags:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correct tax-inclusive price w/in $0.25</td>
<td>0.75</td>
<td>1.00</td>
<td>0.43</td>
</tr>
</tbody>
</table>

T-test for equality of means: $p < 0.001$

N=49

Students were asked to choose two items from image.

Asked to report “Total bill due at the register for these two items.”

Source: Chetty, Looney, and Kroft (2009)
Chetty et al.: Research Design

- Quasi-experimental difference-in-differences

- Treatment group:
  - *Products*: Cosmetics, Deodorants, and Hair Care Accessories
  - *Store*: One large store in Northern California
  - *Time period*: 3 weeks (February 22, 2006 – March 15, 2006)

- Control groups:
  - *Products*: Other prods. in same aisle (toothpaste, skin care, shave)
  - *Stores*: Two nearby stores similar in demographic characteristics
  - *Time period*: Calendar year 2005 and first 6 weeks of 2006
### Effect of Posting Tax-Inclusive Prices: Mean Quantity Sold

<table>
<thead>
<tr>
<th>Period</th>
<th>Control Categories</th>
<th>Treated Categories</th>
<th>Difference</th>
<th>( DD_{TS} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>26.48 (0.22)</td>
<td>25.17 (0.37)</td>
<td>-1.31 (0.43)</td>
<td></td>
</tr>
<tr>
<td>Experiment</td>
<td>27.32 (0.87)</td>
<td>23.87 (1.02)</td>
<td>-3.45 (0.64)</td>
<td></td>
</tr>
<tr>
<td>Difference over time</td>
<td>0.84 (0.75)</td>
<td>-1.30 (0.92)</td>
<td>( DD_{TS} = -2.14 )</td>
<td>(0.64)</td>
</tr>
</tbody>
</table>

Source: Chetty, Looney, and Kroft (2009)
### TREATMENT STORE

<table>
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### CONTROL STORES

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<td>30.76 (0.72)</td>
<td>28.19 (1.06)</td>
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<tr>
<td>Difference</td>
<td>0.19 (0.64)</td>
<td>0.25 (0.92)</td>
<td>DD_{CS} = 0.06</td>
</tr>
<tr>
<td>over time</td>
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<td>(0.90)</td>
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### Effect of Posting Tax-Inclusive Prices: Mean Quantity Sold

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<td></td>
</tr>
</tbody>
</table>

DDD Estimate: \( -2.20 \) (0.58)

Source: Chetty, Looney, and Kroft (2009)
Chetty et al.: Strategy 2

- Compare effects of price changes and tax changes

- Alcohol subject to two state-level taxes in the U.S.:
  - Excise tax: included in price
  - Sales tax: added at register, not shown in posted price

- Exploiting state-level changes in these two taxes, estimate $\theta$
  - Addresses concern that experiment may have induced a “Hawthorne effect”
Per Capita Beer Consumption and State Beer Excise Taxes

Source: Chetty, Looney, and Kroft (2009)
Per Capita Beer Consumption and State Sales Taxes

Change in Log(1+Sales Tax Rate)
Change in Log Per Capita Beer Consumption

Source: Chetty, Looney, and Kroft (2009)
### Effect of Excise and Sales Taxes on Beer Consumption

<table>
<thead>
<tr>
<th>Dependent Variable: $\Delta \log(\text{per capita beer consumption})$</th>
<th>Baseline</th>
<th>Bus Cyc, Alc Regs.</th>
<th>3-Year Diffs</th>
<th>Food Exempt</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta \log(1+\text{Excise Tax Rate})$</td>
<td>-0.87</td>
<td>-0.89</td>
<td>-1.11</td>
<td>-0.91</td>
</tr>
<tr>
<td></td>
<td>(0.17)***</td>
<td>(0.17)***</td>
<td>(0.46)**</td>
<td>(0.22)***</td>
</tr>
<tr>
<td>$\Delta \log(1+\text{Sales Tax Rate})$</td>
<td>-0.20</td>
<td>-0.02</td>
<td>-0.00</td>
<td>-0.14</td>
</tr>
<tr>
<td></td>
<td>(0.30)</td>
<td>(0.30)</td>
<td>(0.32)</td>
<td>(0.30)</td>
</tr>
<tr>
<td>Business Cycle Controls</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Alcohol Regulation Controls</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Year Fixed Effects</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>F-Test for Equality of Coeffs.</td>
<td>0.05</td>
<td>0.01</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td>Sample Size</td>
<td>1,607</td>
<td>1,487</td>
<td>1,389</td>
<td>937</td>
</tr>
</tbody>
</table>

Source: Chetty, Looney, and Kroft (2009)
Tax Incidence with Salience Effects

- Let \( \{x(p, t, Z), y(p, t, Z)\} \) denote empirically observed demands.

- Place no structure on these demand functions except for feasibility:
  \[
  (p + t)x(p, t, Z) + y(p, t, Z) = Z
  \]

- Demand functions taken as empirically estimated objects rather than optimized demand from utility maximization.

- Supply side model same as above.

- Market clearing price \( p \) satisfies
  \[
  D(p, t, Z) = S(p)
  \]
  where \( D(p, t, z) = x(p, t, z) \) is market demand for \( x \).
Tax Incidence with Salience Effects

1 – excess supply of E created by imposition of tax
2 – re-equilibration of market through pre-tax price cut

\[
dp = \frac{E}{\frac{\partial S}{\partial p} - \frac{\partial D}{\partial p}}
\]

\[
\Rightarrow dp/dt^S = \frac{\partial D}{\partial t^S} \frac{1}{\left(\frac{\partial S}{\partial p} - \frac{\partial D}{\partial p}\right)}
\]

\[
E = t^S \frac{\partial D}{\partial t^S}
\]

Source: Chetty, Looney, and Kroft (2009)
Incidence on producers of increasing $t$ is

$$\frac{dp}{dt} = \frac{\partial D/\partial t}{\partial S/\partial p - \partial D/\partial p} = -\theta \frac{\varepsilon_D}{\varepsilon_S - \varepsilon_D}$$

1. Incidence on producers attenuated by $\theta$

2. No tax neutrality: taxes on producers have greater incidence on producers than non-salient taxes levied on consumers

Intuition: Producers need to cut pretax price less when consumers are less responsive to tax
An empirical application

1. [Evans, Ringel, and Stech 1999]: Cigarette excise taxes
Cigarette Taxation: Background

- Cigarettes are heavily taxed in many countries

- Generates around $15 billion in tax revenue in US, about as much as estate taxation

- Taxed at both federal and state levels

- Federal tax is $0.24 per pack with $7.3 billion raised in 1996

- Each state also applies specific excise taxes

- Variation among states: from 2.5 cents per pack in VA to $1.00 in AK
Cigarette Taxation: Background

- Since 1975, close to 200 state tax changes → natural experiments to investigate tax incidence

- Note that over the last 50 years, many increases in taxes but real tax flat because of inflation erosion

- Controversial commodity due to health and paternalism concerns

- Policy question: How do tax increases affect prices? Do they take money from cigarette companies?

- Partial equilibrium is a plausible approximation for cigarettes → good example with which to start
Evans, Ringel, and Stech (1999)

- Exploit state-level changes in excise tax rates to characterize aggregate market for cigarettes (prices, quantities)
- Provides a good introduction to standard diff-in-diff methods
- Idea: Suppose federal govt. implements a tax change. Compare cigarette prices before and after the change

\[ D = [P_{A1} - P_{A0}] \]

- Underlying assumption: absent the tax change, there would have been no change in cigarette price.
Difference-in-Difference

- But what if price fluctuates because of climatic conditions, or if there is an independent trend in demand?

  → First difference (and time series) estimate biased

- Can improve on the difference by using diff-in-diff

\[
DD = [P_{A1} - P_{A0}] - [P_{B1} - P_{B0}]
\]

- State A: experienced a tax change (treatment)

- State B: does not experience any tax change (control)

- Identifying assumption: “parallel trends:” absent the policy change, \( P_1 - P_0 \) would have been the same for A and B
Source: Evans, Ringel, and Stech 1999
Parallel Trend Assumption

- Can use placebo $DD$ to test parallel trend assumption

- Compute $DD$ for prior periods→if not zero, then $DD_{t=1}$ prob. biased
  
  - Useful to plot long time series of outcomes for treatment and control
  
  - Pattern should be parallel lines, with sudden change just after reform

- Want treat. and cntrl. as similar as possible

- Can formalize this logic using a permutation test: pretend reform occurred at other points and replicate estimate
Some studies use a “triple difference” ($DDD$)

Chetty, Looney, Kroft (2009): experiment using treatment/control products, treatment/control stores

$$DDD = DD_{TS} - DD_{CS}$$

$DD_{TS}$: difference of treat., cntrl products in treat. store

$DD_{CS}$: difference of treat., cntrl. products in cntrl. store

$DDD$ is mainly useful only as a robustness check:

- $DD_{CS} \neq 0$, unconvincing that $DDD$ removes all bias
- $DD_{CS} = 0$, then $DD = DDD$ but $DD$ has smaller s.e.
ERS have data for 50 states, 30 years, and many tax changes

Want to pool all this data to obtain single incidence estimate

Fixed effects: generalize $DD$ with $S > 2$ periods and $J > 2$ groups

Suppose that group $j$ in year $t$ experiences policy $T$ of intensity $T_{jt}$

Want to identify effect of $T$ on price $P$. OLS regression:

$$P_{jt} = \alpha + \beta T_{jt} + \epsilon_{jt}$$

With no fixed effects, the estimate of $\beta$ is biased if treatment $T_{jt}$ is correlated with $\epsilon_{jt}$

Often the case in practice - states with taxes differ in many ways (e.g. more anti-tobacco campaigns)
Fixed Effects

- Include time and state dummies as a way of solving this problem:

\[ P_{jt} = \alpha + \gamma_t + \delta_j + \beta T_{jt} + \epsilon_{jt} \]

- Fixed effect regression is equivalent to partial regression

\[ \hat{P}_{jt} = \beta \hat{T}_{jt} + \epsilon_{jt} \]

where \( \hat{P}_{jt} = P_{jt} - P_j - P_t \) and \( \hat{T}_{jt} \) is defined analogously

- Identification obtained from within-state variation over time

- Note: common changes that apply to all groups (e.g. fed tax change) captured by time dummy; not a source of variation that identifies \( \beta \)
Fixed Effects vs. Difference-in-Difference

- Advantage relative to \textit{DD}: more precise, robust results

- Disadvantage: fixed effects is a black-box regression, more difficult to check trends visually as can be done with a single change
  
  → Combine it with simple, graphical, non-parametric evidence

- Same parallel trends identification assumption as DD

  - Potential violation: policy reforms may respond to trends in outcomes

  - Ex: tobacco prices increase → state decides to lower tax rate
Evans, Ringel, and Stech (1999)

- Implement a fixed effects model for prices
- Regress price on state/year fixed effects, covariates, and tax rate (in cents)
- Also estimate demand elasticities using fixed effects estimator
- Regress log quantity consumed on state/year fixed effects, covariates, and real tax rate (in cents)
### TABLE 2
**OLS Estimates, Retail Price Model: Tobacco Institute Data**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nominal (1)</td>
<td>Real (2)</td>
</tr>
<tr>
<td>Nominal/real tax</td>
<td>1.01</td>
<td>0.92</td>
</tr>
<tr>
<td></td>
<td>(0.04)</td>
<td>(0.04)</td>
</tr>
<tr>
<td>Nominal/real wholesale price</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.972</td>
<td>0.933</td>
</tr>
<tr>
<td>Observations</td>
<td>612</td>
<td>612</td>
</tr>
</tbody>
</table>

Standard errors in parentheses. Real prices in 1997 cents/pack. Models in columns (1) and (2) control for state effects.

Source: Evans, Ringel, and Stech 1999
100% pass through implies supply elasticity of $\varepsilon_s = \infty$ at state level

Could be different at national level

Important to understand how the variation you are using determines what parameter you are identifying
### TABLE 3

**OLS Estimates, Log Per Capita Consumption Model, Tobacco Institute Data, 1985–1996**

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Coefficients (standard errors) on</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Real tax</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td>Current value</td>
<td>$-0.254 \pm 0.037$</td>
</tr>
<tr>
<td>1-year lag</td>
<td>$-0.215 \pm 0.413$</td>
</tr>
<tr>
<td>2-year lag</td>
<td>$-0.061 \pm 0.045$</td>
</tr>
<tr>
<td>Price elasticity</td>
<td>$-0.424 \pm 0.062$</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.975</td>
</tr>
</tbody>
</table>

Source: Evans, Ringel, and Stech 1999
Demand model estimate implies that: $\varepsilon_D = -0.42$

$\rightarrow$ 10% increase in price induces a 4.2% reduction in consumption

Tax passed 1-1 onto consumers, so we can compute $\varepsilon_D$ from $\hat{\beta}$ in demand model:

$$\varepsilon_D = \frac{P \Delta Q}{Q \Delta T} = \frac{\hat{\beta}}{(\Delta T / P)}$$

taking $P$ and $Q$ average values in the data

Can substitute $\Delta P = \Delta T$ here because of 1-1 pass through
IV Estimation of Price Elasticities

- How to estimate price elasticity of demand when tax and prices do not move together 1-1?

- Standard technique: instrument for prices using taxes

- First stage, taking note of F-stat:

\[ P_{jt} = \alpha' + \gamma'_t + \delta'_j + \beta T_{jt} + \epsilon_{jt} \]

- Second stage:

\[ Q_{jt} = \alpha + \gamma_t + \delta_j + \lambda \hat{P}_{jt} + \epsilon_{jt} \]

- Reduced form, using \( T_{jt} \) as an instrument for \( P_{jt} \):

\[ Q_{jt} = \alpha + \gamma_t + \delta_j + \mu T_{jt} + \epsilon_{jt} \]

- 2SLS regression coefficient:

\[ \hat{\lambda} = \hat{\mu} / \hat{\beta} \]
Evans, Ringel, and Stech: Long Run Elasticity

- *DD* before and after one year captures short term response: effect of current price $P_{jt}$ on current consumption $Q_{jt}$

- F.E. also captures short term responses

- What if full response takes more than one period? Especially important considering nature of cigarette use

- F.E. estimate biased. One solution: include lags ($T_{j,t-1}, T_{j,t-2}, ...$).

- Are identification assumptions still valid here? Tradeoff between LR and validity of identification assumptions
Use individual data to see who smokes by education group and income level

Spending per capita decreases with the income level

Tax is regressive on an absolute level (not only that share of taxes relative to income goes down)

Conclusion: Taxes/fines levied on cigarette companies lead to poor paying more for same goods, with no impact on companies!
FIGURE 8. Smoking Rates by Income Quartiles and Age—1992–1993 CPS TUS

Source: Evans, Ringel, and Stech 1999
Cigarette Tax Incidence: Other Considerations

1. Lifetime vs. current incidence (Poterba 1989)
   - Finds cigarette, gasoline and alcohol taxation are less regressive (in statutory terms) from a lifetime perspective.
   - High corr. between income and cons share in cross-section; weaker corr. with permanent income.

2. Behavioral models (Gruber and Koszegi 2004)
   - If agents have self control problems, incidence conc. on poor is beneficial to the extent that they smoke less.

   - Use data on cotinine (biomarker) levels in lungs to measure inhalation.
   - Higher taxes lead to fewer cigarettes smoked but no effect on cotinine in lungs, implying longer inhalation of each cigarette.
Market rigidities:

- With price floors, incidence can differ
- Consider incidence of social security taxes with minimum wage
- Statutory incidence: 6.2% on employer and 6.2% on employee
- Share of each should not matter as long as total is constant because wages will fall to adjust
- But with binding minimum wage, employers cannot cut wage further, so statutory incidence determines economic incidence on the margin
Extensions of Basic Partial Equilibrium Analysis

1. Market rigidities

2. Imperfect competition

- Overshifting: possible to get an increase in after-tax price > level of the tax
- Ad valorem and excise taxation are no longer equivalent
- See Salanie text
Extensions of Basic Partial Equilibrium Analysis

1. Market rigidities

2. Imperfect competition

3. Effects on other markets:
   - Increase in cigarette tax → substitute cigarettes for cigars, increasing price of cigars and shifting cigarette demand curve
   - Revenue effects on other markets: tax increases make agents poorer; less to spend on other markets
   - This motivates general equilibrium analysis of incidence
General Equilibrium Analysis

- Trace out full incidence of taxes back to original owners of factors
- Partial equilibrium: “producer” vs. consumer
- General equilibrium: capital owners vs. labor vs. landlords, etc.

Two types of models:

1. **Static**: many sectors or many factors of production
   - Workhorse analytical model: Harberger (1962): 2 sector and 2 factors of production
   - Computational General Equilibrium: many sectors, many factors of production model

2. **Dynamic**
   - Intergenerational incidence: Soc Sec reform
   - Asset price effects: capitalization
1. Fixed total supply of labor $L$ and capital $K$ (short-run, closed economy)

2. Constant returns to scale in both production sectors

3. Full employment of $L$ and $K$

4. Firms are perfectly competitive

   Implicit assumption: no adjustment costs for capital and labor
Harberger Model: Setup

- Production in sectors 1 (bikes) and 2 (cars):
  \[ X_1 = F_1(K_1, L_1) = L_1 f(k_1) \]
  \[ X_2 = F_2(K_2, L_2) = L_2 f(k_2) \]
  with full employment conditions \( K_1 + K_2 = K \) and \( L_1 + L_2 = L \)

- Factors \( w \) and \( L \) fully mobile → in eq., returns must be equal:
  \[ w = p_1 F_{1L} = p_2 F_{2L} \]
  \[ r = p_1 F_{1K} = p_2 F_{2K} \]

- Demand functions for goods 1 and 2:
  \[ X_1 = X_1(p_1 / p_2) \text{ and } X_2 = X_2(p_1 / p_2) \]

- Note: all consumers identical so redistribution of incomes via tax system does not affect demand via a feedback effect

- System of ten eq’ns and ten unknowns: \( K_i, L_i, p_i, X_i, w, r \)
Introduce small tax $d\tau$ on rental of capital in sector 2 ($K_2$)

All eqns the same as above except $r = (1 - d\tau)p_2F_{2K}$

Linearize the 10 eq’ns around initial equilibrium to compute the effect of $d\tau$ on all 10 variables ($dw, dr, dL_1, ...$)

Labor income = $wL$ with $L$ fixed, $rK$ = capital income with $K$ fixed

Therefore change in prices $dw/d\tau$ and $dr/d\tau$ describes how tax is shifted from capital to labor

Changes in prices $dp_1/d\tau$, $dp_2/d\tau$ describe how tax is shifted from sector 2 to sector 1

Kotlikoff and Summers (Section 2.2) state linearized equations as a fn. of substitution elasticities
Harberger Model: Main Effects

1. **Substitution effects**: capital bears incidence

   - Tax on $K_2$ shifts production in Sector 2 away from $K$ so aggregate demand for $K$ goes down
   - Because total $K$ is fixed, $r$ falls $\rightarrow$ $K$ bears some of the burden
2. **Output effects**: capital may not bear incidence

- Tax on $K_2$ implies that sector 2 output becomes more expensive relative to sector one
- Therefore demand shifts toward sector 1

**Case 1**: $K_1/L_1 < K_2/L_2$ (1: bikes, 2: cars)

- Sector 1 is less capital intensive so aggregate demand for $K$ goes down
- Output effect reinforces subst effect: $K$ bears the burden of the tax

**Case 2**: $K_1/L_1 > K_2/L_2$ (1: cars, 2: bikes)

- Sector 1 is more capital intensive, aggregate demand for $K$ increases
- Subst. and output effects have opposite signs; labor may bear some or all the tax
3. **Substitution + Output = Overshifting effects**

- **Case 1:** $K_1 / L_1 < K_2 / L_2$
  - Can get overshifting of tax, $dr < -d\tau$ and $dw > 0$
  - Capital bears more than 100% of the burden if output effect sufficiently strong
  - Taxing capital in sector 2 raises prices of cars $\rightarrow$ more demand for bikes, less demand for cars
  - With very elastic demand (two goods are highly substitutable), demand for labor rises sharply and demand for capital falls sharply
  - Capital loses more than direct tax effect and labor suppliers gain
3. **Substitution + Output = Overshifting effects**

- **Case 2:** $K_1/L_1 > K_2/L_2$
  
  - Possible that capital is made better off by capital tax
  
  - Labor forced to bear more than 100% of incidence of capital tax in sector 2
  
  - Ex. Consider tax on capital in bike sector: demand for bikes falls, demand for cars rises
  
  - Capital in greater demand than it was before $\rightarrow$ price of labor falls substantially, capital owners actually gain

- Bottom line: taxed factor may bear less than 0 or more than 100% of tax.
Harberger Two Sector Model

- Theory not very informative: model mainly used to illustrate negative result that “anything goes”

- More interest now in developing methods to identify what actually happens

- Original Application of this framework by Harberger: sectors = housing and corporations

- Capital in these sectors taxed differently because of corporate income tax and many tax subsidies to housing
  - Ex: Deductions for mortgage interest and prop. tax are about $50 bn total

- Harberger made assumptions about elasticities and calculated incidence of corporate tax given potential to substitute into housing
Harberger analyzed two sectors; subsequent literature expanded analysis to multiple sectors

Analytical methods infeasible in multi-sector models

Instead, use numerical simulations to investigate tax incidence effects after specifying full model

Pioneered by Shoven and Whalley (1972). See Kotlikoff and Summers section 2.3 for a review

Produced a voluminous body of research in PF, trade, and development economics
CGE Models: General Structure

- $N$ intermediate production sectors
- $M$ final consumption goods
- $J$ groups of consumers who consume products and supply labor
  
  Each industry has different substitution elasticities for capital and labor
  
  Each consumer group has Cobb-Douglas utility over $M$ consumption goods with different parameters
  
  Specify all these parameters (calibrated to match some elasticities) and then simulate effects of tax changes
Criticism of CGE Models

- Findings very sensitive to structure of the model: savings behavior, perfect competition assumption

- Findings sensitive to size of key behavioral elasticities and functional form assumptions

- Modern econometric methods conceptually not suitable for GE problems, where the whole point is “spillover effects” (contamination)

- Need a new empirical paradigm to deal with these problems – a major open challenge
General Equilibrium Incidence in Dynamic Models

• Static analysis above assumes that all prices and quantities adjust immediately

• In practice, adjustment of capital stock and reallocation of labor takes time

• Dynamic CGE models incorporate these effects; even more complex
  • Static model can be viewed as description of steady states
  • During transition path, measured flow prices \((r, w)\) will not correspond to steady state responses

• How to measure incidence in dynamic models?
Capitalization and the Asset Price Approach

- Asset prices can be used to infer incidence in dynamic models (Summers 1983)
  - Study effect of tax changes on asset prices
  - Asset prices adjust *immediately* in efficient markets, incorporating the full present-value of subsequent changes
  - Efficient asset markets incorporate all effects on factor costs, output prices, etc.

- Limitation: can only be used to characterize incidence of policies on capital owners
  - There are no markets for individuals
Simple Model of Capitalization Effects

- Firms pay out profits as dividends
- Profits determined by revenues net of factor payments:
  \[ V = \sum \frac{D_t}{1 + r} = \sum \frac{q_t X_t - w_{jt} L_{jt}}{1 + r} \]
- Change in valuation of firm (\( \frac{dV}{dt} \)) reflects change in present value of profits
- \( \frac{dV}{dt} \) is a sufficient statistic that incorporates changes in all prices
- Empirical applications typically use “event study” methodology
- Examine pattern of asset prices or returns over time, look for break at time of announcement of policy change
- Problem: clean shocks are rare; big reforms do not happen suddenly and are always expected to some extent
Empirical Applications


2. [Linden and Rockoff 2008] Effect of a sex offender moving into neighborhood on home values

3. [Friedman 2008] Effect of Medicare Part D on drug companies
Looks at the Tax Reform Act of 1986, which:

1. Decreased the tax rate on corporate income
2. Repealed the investment tax credit and reduced depreciation allowances

These changes hurt companies with higher levels of current investment

Examines daily returns of 350 firms, $R_{it}$
First, compute excess return ($\hat{\epsilon}_{is}$) for each firm $i$ by regressing:

$$R_{it} = \alpha + \beta_i R_{Mt} + \epsilon_{it}$$

Obtain excess return $\hat{\epsilon}_{is}$: return purged of market trends

Here, events are the dates when TRA was voted on in the House and Senate

Compute the average excess return in a ± 10 day window for each firm $Excess_i = \hat{\epsilon}_{is}$ where $s$ is the time of the event

Second step regression:

$$Excess_i = a + b (Inv/K)_{i} + \nu_i$$

where $(Inv/K)_{i}$ is a measure of the rate of investment of firm $i$

Theory predicts $b < 0$
<table>
<thead>
<tr>
<th>Period</th>
<th>Machinery and Equipment Share</th>
<th>Rate of Investment</th>
<th>Net Capital Stock</th>
<th>Average Tax Rate</th>
<th>Predicted Change In Cash Flow</th>
<th>Industry Dummies</th>
<th>$R^2$</th>
<th>$N$</th>
</tr>
</thead>
<tbody>
<tr>
<td>One Day</td>
<td>.018</td>
<td>-.004</td>
<td>.037</td>
<td>-.002</td>
<td>-.045</td>
<td>No</td>
<td>.022</td>
<td>336</td>
</tr>
<tr>
<td></td>
<td>(.012)</td>
<td>(.006)</td>
<td>(.033)</td>
<td>(.004)</td>
<td>(.064)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One Day</td>
<td>.000</td>
<td>-.003</td>
<td>.032</td>
<td>-.003</td>
<td>-.044</td>
<td>Yes</td>
<td>.097</td>
<td>336</td>
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<tr>
<td></td>
<td>(.015)</td>
<td>(.006)</td>
<td>(.036)</td>
<td>(.005)</td>
<td>(.066)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ten Days</td>
<td>.083</td>
<td>-.029</td>
<td>.068</td>
<td>-.009</td>
<td>-.126</td>
<td>No</td>
<td>.061</td>
<td>333</td>
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<tr>
<td></td>
<td>(.025)</td>
<td>(.013)</td>
<td>(.070)</td>
<td>(.010)</td>
<td>(.141)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ten Days</td>
<td>.035</td>
<td>-.028</td>
<td>.044</td>
<td>-.011</td>
<td>-.166</td>
<td>Yes</td>
<td>.205</td>
<td>333</td>
</tr>
<tr>
<td></td>
<td>(.031)</td>
<td>(.013)</td>
<td>(.075)</td>
<td>(.010)</td>
<td>(.139)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One Month</td>
<td>.064</td>
<td>-.131</td>
<td>-.025</td>
<td>-.028</td>
<td>-.173</td>
<td>No</td>
<td>.052</td>
<td>330</td>
</tr>
<tr>
<td></td>
<td>(.043)</td>
<td>(.042)</td>
<td>(.117)</td>
<td>(.016)</td>
<td>(.318)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One Month</td>
<td>.024</td>
<td>-.158</td>
<td>-.027</td>
<td>-.028</td>
<td>.115</td>
<td>Yes</td>
<td>.174</td>
<td>330</td>
</tr>
<tr>
<td></td>
<td>(.051)</td>
<td>(.044)</td>
<td>(.124)</td>
<td>(.016)</td>
<td>(.323)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cutler: Results

- Cutler finds $\hat{b} = -0.029(0.013)$

- This is consistent with expectations, but other findings are not:
  - Changes in future tax liabilities not correlated with stock value changes
  - Responses to two distinct events (passage of bill in House and Senate) not correlated
  - Were the votes really surprises? Need data on expectations

- Study is somewhat inconclusive because of noisy data

- But led to a subsequent better-identified literature
Another common application is to housing market to assess WTP for amenities.

Examples: pollution, schools, crime.


Identification strategy: look at how house prices change when a registered sex offender moves into a neighborhood.

Data: public records on offender’s addresses and property values in North Carolina.
Illustration of Identification Strategy

Source: Linden and Rockoff 2008.
Illustration of Identification Strategy

Source: Linden and Rockoff 2008.
Figure 3a: Price Trends Before and After Offenders’ Arrivals Parcels Within Tenth Mile of Offender Location

Note: Results from local polynomial regressions (bandwidth=90 days) of sale price on days before/after offender arrival.

Source: Linden and Rockoff 2008.
Figure 3b: Price Trends Before and After Offenders’ Arrivals Parcels Within 1/3 Mile of Offender Location

Source: Linden and Rockoff 2008.
Linden and Rockoff: Results

- Find house prices decline by about 4% ($5500) when a sex offender is located within 0.1 mile of the house.

- Implied cost of a sexual offense given probabilities of a crime: $1.2 million.

- This is far above what is used by Dept of Justice.

- How to interpret evidence: true cost of crime or a behavioral effect?
  - Why does price fall only within 0.1 mile radius?
Mandated Benefits

- We have focused until now on incidence of price interventions (taxes, subsidies)

- Similar incidence/shifting issues arise in analyzing quantity intervention (regulations)

- Leading case: mandated benefits – requirement that employers pay for health care, workers compensation benefits, child care, etc.

- Mandates are attractive to government because they are “off budget”; may reflect salience issues
Mandated Benefits

- Tempting to view mandates as additional taxes on firms and apply same analysis as above.

- But mandated benefits have different effects on equilibrium wages and employment differently than a tax (Summers 1989).

- Key difference: mandates are a benefit for the worker, so effect on market equilibrium depends on benefits workers get from the program.

- Unlike a tax, may have no distortionary effect on employment and only an incidence effect (lower wages).
Mandated Benefits: Simple Model

- Labor demand ($D$) and labor supply ($S$) are functions of the wage, $w$
- Initial equilibrium:
  \[ D(w_0) = S(w_0) \]
- Now, govt mandates employers provide a benefit with cost $t$
- Workers value the benefit at $\alpha t$ dollars
- Typically $0 < \alpha < 1$ but $\alpha > 1$ possible with market failures
- Labor cost is now $w + t$, effective wage $w + \alpha t$
- New equilibrium:
  \[ D(w + t) = S(w + \alpha t) \]
Mandated Benefit

Wage Rate

Labor Supply

$w_1$

$L_1$

$D_1$

$S$

Point A
Mandated Benefit

- Wage Rate
- Labor Supply

$1

Point A

Point B

Point D_2

Point L_1

Public Economics Lectures
Tax & Expenditure Incidence
Mandated Benefit

- Wage Rate
- Labor Supply

$w_1, w_2, L_1, D_1, S, D_2$

$\alpha$

$A$

$B$

$C$

$D_2$

$L_1$

$\alpha$

$1$

Public Economics Lectures

Tax & Expenditure Incidence
Mandated Benefits: Incidence Formula

- Analysis for a small $t$: linear expansion around initial equilibrium

\[
(dw / dt + 1)D' = (dw / dt + \alpha)S'
\]

\[
dw / dt = (D' - \alpha S') / (S' - D')
\]

\[
= -1 + (1 - \alpha) \frac{\eta_S}{\eta_S - \eta_D}
\]

where

\[
\eta_D = wD' / D < 0
\]

\[
\eta_S = wS' / S > 0
\]

- If $\alpha = 1$, $dw / dt = -1$ and no effect on employment

- More generally: $0 < \alpha < 1$ equivalent to a tax $1 - \alpha$ with usual incidence and efficiency effects
Empirical Applications

1. [Gruber 1994] Pregnancy health insurance costs
2. [Acemoglu and Angrist 2001] Americans with Disabilities Act
Gruber 1994

- Studies state mandates for employer-provided health insurance to cover pregnancy costs
- In 1990, expected cost for pregnancy about $500 per year for married women aged 20 to 40
- State law changes to mandate coverage of pregnancy costs in 1976
Uses difference-in-difference estimator:

\[ DD^T = [W_{YA} - W_{YB}] - [W_{NA} - W_{NB}] \]

Time periods: before 1974-75 (B), after 1977-78 (A)

Three experimental states (Y): IL, NJ, and NY

Five nearby control states (N)

Concern: differential evolution of wages in control vs. treatment states

Placebo \( DD^C \) for control group: people over 40 and single males aged 20-40

\[ DDD = DD^T - DD^C \]
### Table 3—DDD Estimates of the Impact of State Mandates on Hourly Wages

<table>
<thead>
<tr>
<th>Location/year</th>
<th>Before law change</th>
<th>After law change</th>
<th>Time difference for location</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Treatment Individuals: Married Women, 20 – 40 Years Old:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental states</td>
<td>1.547 (0.012)</td>
<td>1.513 (0.012)</td>
<td>−0.034 (0.017)</td>
</tr>
<tr>
<td></td>
<td>[1,400]</td>
<td>[1,496]</td>
<td></td>
</tr>
<tr>
<td>Nonexperimental states</td>
<td>1.369 (0.010)</td>
<td>1.397 (0.010)</td>
<td>0.028 (0.014)</td>
</tr>
<tr>
<td></td>
<td>[1,480]</td>
<td>[1,640]</td>
<td></td>
</tr>
<tr>
<td>Location difference at a point in time:</td>
<td>0.178 (0.016)</td>
<td>0.116 (0.015)</td>
<td></td>
</tr>
<tr>
<td>Difference-in-difference:</td>
<td>−0.062 (0.022)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>B. Control Group: Over 40 and Single Males 20 – 40:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental states</td>
<td>1.759 (0.007)</td>
<td>1.748 (0.007)</td>
<td>−0.011 (0.010)</td>
</tr>
<tr>
<td></td>
<td>[5,624]</td>
<td>[5,407]</td>
<td></td>
</tr>
<tr>
<td>Nonexperimental states</td>
<td>1.630 (0.007)</td>
<td>1.627 (0.007)</td>
<td>−0.003 (0.010)</td>
</tr>
<tr>
<td></td>
<td>[4,959]</td>
<td>[4,928]</td>
<td></td>
</tr>
<tr>
<td>Location difference at a point in time:</td>
<td>0.129 (0.010)</td>
<td>0.121 (0.010)</td>
<td></td>
</tr>
<tr>
<td>Difference-in-difference:</td>
<td>−0.008: (0.014)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DDD:**

−0.054 (0.026)

**Source:** Gruber 1994.
Find $DD^T = -0.062(0.022), DDD = -0.054(0.026)$

Implies that hourly wage decreases by roughly the cost of the mandate (no distortion case, $\alpha = 1$).

Indirect aggregate evidence also suggests that costs have been shifted on wages.

- Share of health care costs in total employee compensation has increased substantially over last 30 years
- But share of total employee compensation as a share of national income roughly unchanged