

# Tax Incidence

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# Outline

What is tax incidence?

Partial Equilibrium Incidence

Diff-in-diff

Application: Doyle and Samphantharak (2008)

# What is tax incidence?

Tax incidence is the study of the

- ▶ **effects of tax policies on prices and the distribution of welfare.**

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

Examples:

- ▶ impose \$1 per pack tax on cigarettes?
  - ▶ introduce an earnings subsidy (EITC)?
  - ▶ provide a subsidy for food (food stamps)?
- ⇒ distributional effects on smokers, profits of producers, shareholders, farmers,...

This is positive analysis:

- ▶ typically the first step in policy evaluation
- ▶ input to later thinking about what policy maximizes social welfare.

Empirical analysis is a big part of this literature because

- ▶ theory is informative about signs and comparative statics,
- ▶ but largely **inconclusive about magnitudes.**

# What is tax incidence?

Tax incidence is not an accounting exercise but

- ▶ an analytical characterization of **changes in economic equilibria** when taxes are changed.

Key point:

- ▶ **Taxes can be shifted**: taxes affect directly the prices of goods,
  - ▶ which affect quantities because of behavioral responses,
  - ▶ which affect indirectly the price of other goods.

If prices are constant, economic incidence would be the same as legislative incidence.

- ▶ Knowing incidence is incredibly **important for policy analysis**.

# What is tax incidence?

Ideally, we want to know the effect of a tax change on utility levels of all agents in the economy.

- ▶ Realistically, we usually look at impacts on prices or incomes

Useful simplification is to aggregate economic agents into a few groups.

1. gas tax: producers vs consumers
2. tax credit: suppliers vs demanders of labor, recipients vs nonrecipients
3. income tax: rich vs poor
4. property tax: region or country
5. social security: across generations

# Theory: Partial Equilibrium Incidence

Simple model goes a long way to showing main results (Key reference: Kotlikoff & Summers (Hbk, Vol 2, 1987))

- ▶ Two goods:  $x$  and  $y$ 
  - ▶ Government levies an excise tax on good  $x$
  - ▶ Note: **excise taxes** are levied on a quantity (gallon, pack, ton, ...).
    - ▶ Typically fixed in nominal terms (therefore subject to declines in real terms)
  - ▶ Note: **ad-valorem taxes** are a fraction of prices (e.g. sales tax).
    - ▶ Marked automatically to inflation.
- ▶ Let  $y$ , the numeraire good, be untaxed.
- ▶ Let  $x$  have a pretax price  $p$  and purchase price  $q = p + t$ 
  - ▶ Note that statutory incidence is then on the purchaser

## Theory: Partial Equilibrium Incidence

- ▶ Consumer has wealth  $Z$  and utility  $u(x, y)$ .
- ▶ Price-taking firms use  $c(S)$  units of the numeraire  $y$  to produce  $S$  units of  $x$ 
  - ▶ Cost function is  $c(S)$  and is expressed in units of the numeraire.
  - ▶  $c'(S) > 0$  and  $c''(S) \geq 0$ .
  - ▶ Firm profits at pretax price  $p$  and level of supply  $S$  is

$$\pi(S) = pS - c(S).$$

- ▶ Optimally, the supply function for good  $x$  is implicitly defined by the marginal condition

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

Market equilibrium condition:

$$Q = S(p) = D(p + t)$$

- ▶ defines  $p(t)$  as a function of the tax.

We want to characterize  $dp/dt$

- ▶ effect of a tax increase on price
- ▶ determines who effectively bears the burden of tax

Fully differentiating the eq. condition wrt  $t$  and solving for  $dp/dt$ ,

## Theory: Partial Equilibrium Incidence

Now, convert the partial equilibrium result to elasticities

- ▶ these are handy since they are independent of scaling of  $x$  or  $p$ .

*Elasticity*: % change in quantity when price changes by 1 %

- ▶  $\epsilon_D = \frac{\partial D}{\partial p} \cdot \frac{p+t}{D(p+t)}$ : price elasticity of demand.
  - ▶ (consumer face  $q = p + t$ )
- ▶  $\epsilon_S = \frac{\partial S}{\partial p} \cdot \frac{p}{S(p)}$ : price elasticity of supply.

$$\frac{dp}{dt} = \frac{\epsilon_D}{\epsilon_S - \epsilon_D}$$

Note:  $-1 < dp/dt < 0$  and  $dq/dt = 1 + dp/dt$ .

# Theory: Partial Equilibrium Incidence

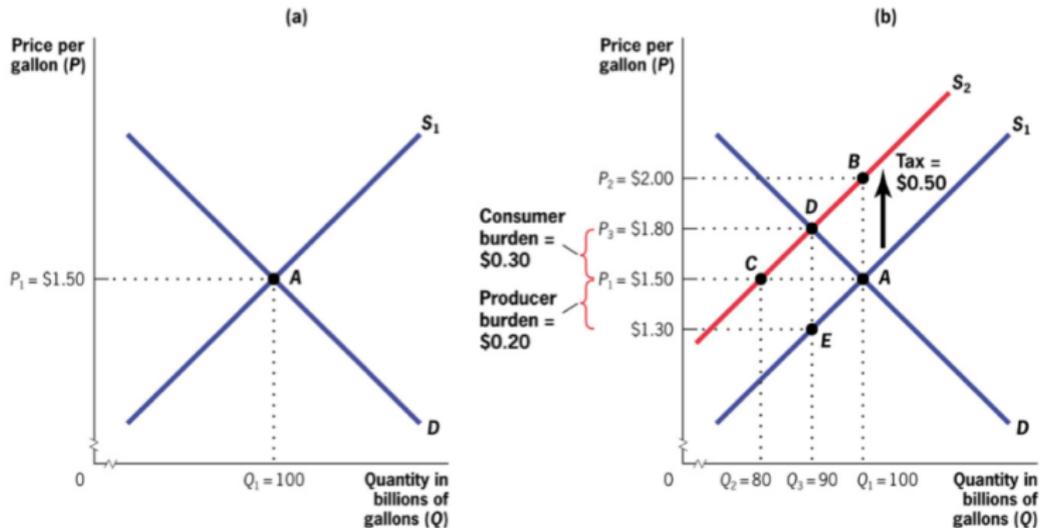


Figure: (Gruber) Tax Levied on Producers

# Theory: Partial Equilibrium Incidence



Figure : (Gruber) Tax Levied on Consumers

Figure: (Gruber) Tax Levied on Consumers

## Theory: Partial Equilibrium Incidence

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

When do consumers bear the entire burden of the tax?

- ▶  $\varepsilon_D = 0$ , i.e. inelastic demand
  - ▶ example: short run demand for gas (need to drive to work)
- ▶  $\varepsilon_S = \infty$ , i.e. perfectly elastic supply
  - ▶ example: perfectly competitive industry

When do producers bear the entire burden of the tax?

- ▶  $\varepsilon_S = 0$ , i.e. inelastic supply
  - ▶ example: fixed quantity supplied (housing?)
- ▶  $\varepsilon_D = \infty$ , i.e. perfectly elastic demand
  - ▶ example: a close substitute is easily available

# Theory: Partial Equilibrium Incidence

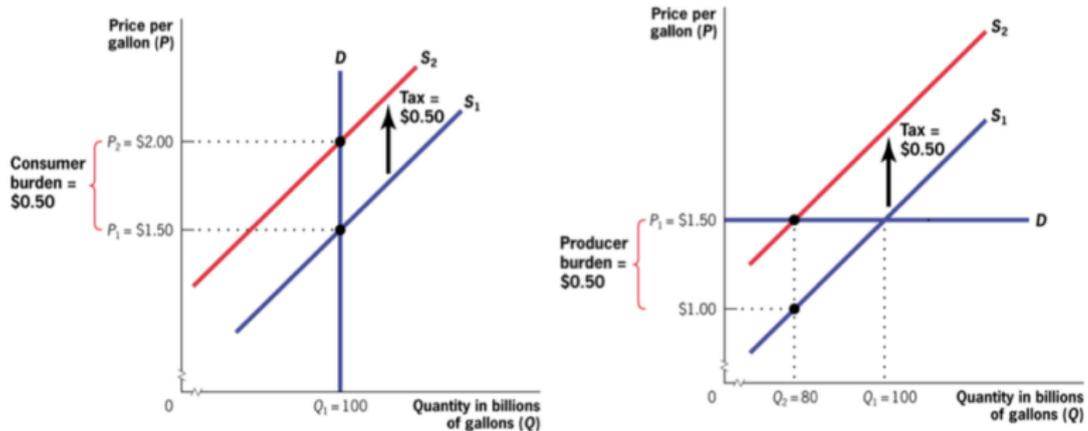


Figure: (Gruber) Inelastic supply/demand curves

# Theory: Partial Equilibrium Incidence

Key intuitions:

1. statutory incidence not equal to economic incidence
  2. equilibrium is independent of who nominally pays the tax
  3. more inelastic factor bears more of the tax
- ⇒ These are robust conclusions that hold with more complicated models

Extensions to partial equilibrium incidence:

- ▶ Standard analysis assumes prices and taxes affect demand in the same way:  $dx = dx$  .
  - ▶ Chetty, Looney & Kroft (AER 2008) generalize theory to allow for salience effects.
- ▶ Market rigidities: With a minimum or maximum price, the former analysis may not be correct.
  - ▶ Example: minimum wage. Social security taxes 7.5% on employer and 7.5% on employee.
  - ▶ In principle the share of each should not matter as long as total is constant
  - ▶ but minimum wage is computed on net wage (gross wage - employer tax = net wage + employee tax).

# Theory: Partial Equilibrium Incidence

Extensions to partial equilibrium incidence (continued):

- ▶ Imperfect competition such as monopoly. Possible to get an increase in after-tax price bigger than the level of the tax.
  - ▶ Ad valorem and excise taxation are no longer equivalent.
- ▶ Ignores effects on other markets:
  - ▶ E.g., say cigarette tax increases, if people substitute cigarettes for cigars then price of cigars increases and part of the burden is shifted to the cigar market and cigarette demand curves will move.
  - ▶ Revenue effects on other markets: tax increases, I am poorer, I have less to spend on other markets.
  - ▶ For small, narrow markets such as cigarettes, partial eq. analysis is probably a reasonable approximation (although effects on substitutes could be important).

# Empirical Applications

Typical empirical evidence on incidence:

- ▶ State panel data
- ▶ Identification is variation across states over time in taxes
- ▶ Challenge is whether tax changes are endogenous
  - ▶ do states make changes in response to current conditions?
  - ▶ usual issue of validity of control group, common trends assumption, etc.

# Introduction

Policies often vary at the aggregate/group level and with time

But unobservables at the group and/or aggregate level may be potential confounders

Methods that address this setup:

- ▶ First differences
- ▶ Difference-in-differences (DID)

These methods exploit data with a time dimension:

- ▶ repeated cross-sections (or panel data)
- ▶ repeated observation of the group, not the individual

## DID: two groups & two time periods

Basic setup:

- ▶ Two groups: treatment group ( $g = A$ ) and control group ( $g = B$ )
- ▶ Two time periods: Before ( $t = 0$ ) and After ( $t = 1$ )

	Before	After	Difference
Treated	$\bar{Y}_{10}$	$\bar{Y}_{11}$	$\Delta_1 = \bar{Y}_{11} - \bar{Y}_{10}$
Control	$\bar{Y}_{00}$	$\bar{Y}_{01}$	$\Delta_0 = \bar{Y}_{01} - \bar{Y}_{00}$
Difference			$DD = \Delta_1 - \Delta_0$

The second diff aims to

- ▶ control for contemporaneous time shocks that are
- ▶ common between the two groups

## DID: Regression set-up

DID-estimator can be obtained by estimating following equation with OLS

$$y_{it} = \beta \cdot Post_t \times Treat_i + \alpha Treat_i + \lambda Post_t + \varepsilon_{it}$$

Advantages of specifying difference-in-difference in a regression equation:

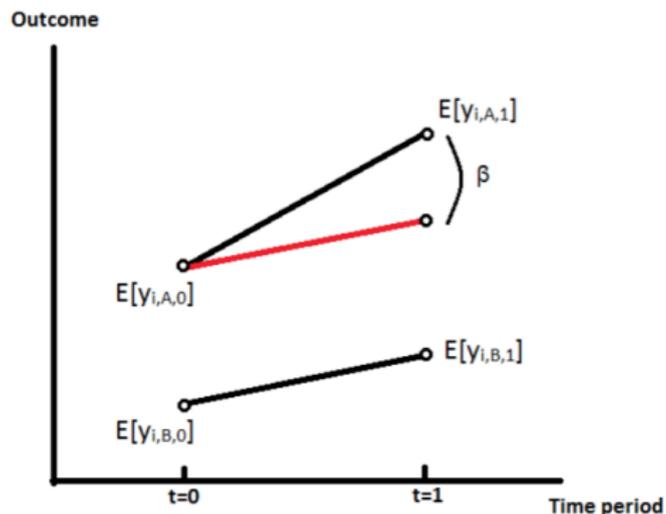
- ▶ easily extended to multiple groups & multiple time periods
  - ▶ replace  $\lambda Post_t$  with time dummies,  $\lambda_t$
- ▶ convenient way to obtain standard errors
- ▶ easy to add additional time-varying regressors
- ▶ treatment variable can be continuous

Main assumption: **In absence of intervention** treatment and control groups would have **common trends**

## DID: Common trend assumption

*In absence of the intervention the treatment and control group(s) should have common trends in the outcome variable*

- ▶ Assumption is **untestable**
- ▶ Common trends prereform increases confidence in assumption



# DID: Composition / Intention-to-treat effects

The treatment under consideration may affect the **composition of the treatment and control groups**

- ▶ Example: a state lowers welfare benefits
  - ▶ this may induce poor families to move to other states
- ▶ Potential solution: (re)define group to be unaffected by treatment
  - ▶ for example pre-treatment state of residence
- ▶ We no longer estimate the treatment effect, but the **intention to treat (ITT)**
  - ▶ needs to be rescaled to provide an estimate of the ATT
  - ▶ e.g. 40% of treated take the pill:  $ATT = \beta/0.4$ 
    - ▶ Note: This is in essence an IV-estimate

## DID: Standard errors and serial correlation

With  $T > 2$  there is likely a serial correlation problem.

Bertrand, Duflo and Mullainathan (QJE, 2004) investigate the consequences of ignoring serial correlation in DID

- ▶ randomly generate placebo laws in state-level data on female wages (50 states, 21 time periods)
- ▶ compute DID estimates and s.e.'s and find an “effect” significant at 5% level in 45 percent of the placebo interventions!

Three factors make serial correlation an important issue for DID

- ▶ DID often based on long time series
- ▶ commonly used outcomes typically highly positively serially correlated
- ▶ treatment variable is highly serially correlated

Solution: **Cluster at the level of the treatment**

- ▶ may be hard to do when treatment is at an aggregated level

# DID: Concluding remarks

## DID estimators

- ▶ can potentially solve causal questions
- ▶ are attractive because they can be implemented with repeated cross sections

## Central identifying assumption is the common trend assumption

- ▶ always think carefully about whether this is a plausible assumption
- ▶ try to provide evidence that there was a common trend in the pre-intervention period
- ▶ be aware of potential composition effects
- ▶ choice of comparison group is crucial!

Make sure to calculate correct standard errors

# Empirical Applications

Plan/template

1. Quick summary
2. Question/setting
3. Treatment
4. Empirical approach
5. Results
6. Interpretation
7. Key specification checks
8. Summary/Implications

# Gas Tax (Doyle and Samphantharak JPubE 2008)

## Question and setting

**Question:** Who bears the burden of the gas tax?

**Setting:** Gas prices spike above \$2.00 in 2000, near election, political desire to provide tax relief

**Treatment:** Repeal and subsequent reinstatement of SALES tax in Indiana (and Illinois)

**Strategy:** Diff-in-diff

What is good about the application:

- ▶ The tax is **salient**: there is attention to prices and government intervention
- ▶ Consider **both a fall and a rise** in prices
  - ▶ asymmetry?
  - ▶ may bound possible bias
- ▶ Governor could act alone so **policy changed quickly**

# Gas Tax (Doyle and Samphantharak JPubE 2008)

## The treatment

What happened to taxes:

- ▶ Indiana (IN) suspends 5% sales tax on gas July 1–Oct 30
  - ▶ extended on August 22 to September 15
  - ▶ extended on September 13 to September 30
  - ▶ extended on September 28 to October 29
- ▶ Illinois (IL) suspends 5% sales tax on gas July 1–Dec 31

Reforms are known to be temporary, but do not apply to some excise taxes

- ▶ sales tax applies to roughly 90 % of the posted price in IL
- ▶ sales tax applies to roughly 80 % of the posted price in IN

Full shifting therefore implies

- ▶ 4.5 % change in price in IL
- ▶ 4 % change in prices in IN

# Gas Tax (Doyle and Samphantharak JPubE 2008)

## Empirical approach

Empirical approach in the paper: DD (RD)

- ▶ Compare treated states with neighboring states (MI, OH, MO, IA, WI)
  - ▶ flexible event time model; looking for sharp discontinuity
  - ▶ start with graphical evidence (unconditional, local linear regression)
  - ▶ next consider regression equation

$$\begin{aligned} \ln(\text{RetailPrice}_{sbt}) = & \gamma_0 + \gamma_1 (\text{IL or IN}) + \gamma_2 \text{PostReform} \\ & + \gamma_3 [(\text{IL or IN}) \times \text{PostReform}] \\ & + \gamma_4 \ln(\text{WholesalePrice}) + \gamma_5 X_s + \delta_b + \epsilon_{sbt} \end{aligned}$$

- ▶ where  $s$  = station,  $b$  = brand,  $t$  = time
- ▶ Note: incidence is measured relative to the tax change
  - ▶  $\frac{\gamma_3}{0.04}$  in Indiana
  - ▶  $\frac{\gamma_3}{0.045}$  in Illinois

# Gas Tax (Doyle and Samphantharak JPubE 2008)

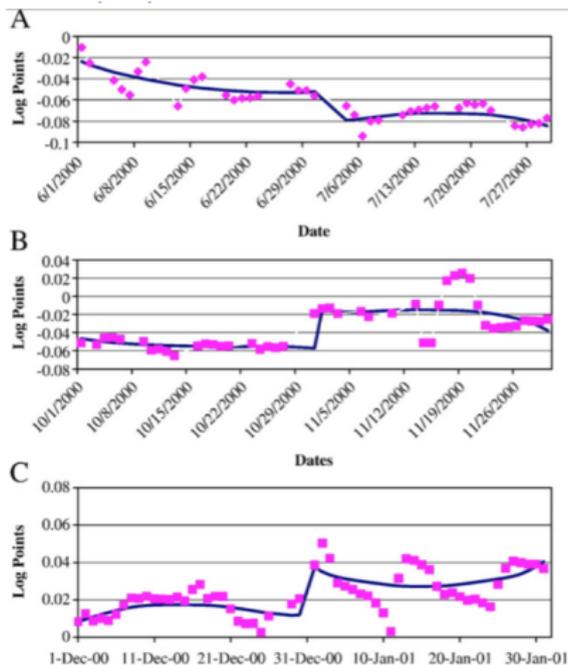
Empirical approach

Control variables used:

- ▶ brand fixed effects
- ▶ wholesale price of gasoline (why separately?)
- ▶ zip code characteristics
  - ▶ population, area
  - ▶ gas stations
  - ▶ income, education, age, race
  - ▶ commuting

# Gas Tax (Doyle and Samphantharak JPubE 2008)

Event study illustration: Diff in  $\ln(\text{price})$  rel. to neighboring states



# Gas Tax (Doyle and Samphantharak JPubE 2008)

Regression results: Tax repeal

Dependent variable	Log (retail price)		Log (wholesale price)	
	(1)	(2)	(3)	(4)
<i>A: July tax repeal</i>				
Illinois or Indiana	-0.048 (0.038)	-0.013 (0.025)	-0.014 (0.021)	-0.035 (0.017)
Post July 1	-0.052 (0.007)	0.029 (0.013)	0.025 (0.015)	-0.088 (0.006)
(IL or IN)* post July 1	-0.035 (0.007)	-0.029 (0.008)	-0.029 (0.008)	-0.007 (0.006)
Observations	29,675	29,675	29,433	29,433
R-squared	0.23	0.60	0.64	0.57
Mean of dep. var.	0.560	0.560	0.560	0.560
Controls:				
Wholesale price	No	Yes	Yes	-
ZIP code characteristics	No	No	Yes	Yes

Panel A: Prices observed June 27, June 28, July 5, July 6; Panel B: Prices observed Oct. 26, Oct. 27, Oct. 31, Nov. 1. Panel C: Prices observed Dec. 29, Dec. 30, Jan. 2, Jan. 3. Standard errors are reported, clustered at the state level.

# Gas Tax (Doyle and Samphantharak JPubE 2008)

## Interpretation

Interpreting estimated effects:

$$\frac{dq}{dt} = \frac{-0.029}{-0.04} = 0.725$$

- ▶ imply a passthrough rate of about 73 %
  - ▶ tax decrease leads to 73 % reduction in price for consumers
- ▶ demand elasticity is thought to range from -0.05 to -0.25

$$\begin{aligned}\frac{dq}{dt} = 0.725 &\implies \frac{dp}{dt} = -0.275 = \frac{\varepsilon_D}{\varepsilon_S - \varepsilon_D} \\ \varepsilon_S - \varepsilon_D &= \varepsilon_D / -0.275 = -3.636\varepsilon_D \\ \varepsilon_S &= -2.636\varepsilon_D \\ &\in (0.132, 0.659)\end{aligned}$$

- ▶ implies supply elasticity btw 0.13 and 0.66
  - ▶ is this reasonable? (smell test)

# Gas Tax (Doyle and Samphantharak JPubE 2008)

Regression results: Tax reinstatement

Dependent variable	Log (retail price)			Log (wholesale price)
	(1)	(2)	(3)	(4)
<i>B: October tax reinstatement</i>				
Indiana	-0.056 (0.009)	-0.052 (0.007)	-0.053 (0.007)	-0.015 (0.001)
Post Oct. 29	-0.014 (0.006)	-0.008 (0.006)	-0.009 (0.006)	-0.021 (0.001)
IN* post Oct. 29	0.039 (0.006)	0.040 (0.007)	0.040 (0.006)	-0.005 (0.002)
Observations	22,092	22,092	21,884	21,884
R-squared	0.16	0.18	0.26	0.41
Mean of dep. var.	0.457	0.457	0.456	0.456
Controls:				
Wholesale price	No	Yes	Yes	-
ZIP code characteristics	No	No	Yes	Yes

Panel A: Prices observed June 27, June 28, July 5, July 6; Panel B: Prices observed Oct. 26, Oct. 27, Oct. 31, Nov. 1. Panel C: Prices observed Dec. 29, Dec. 30, Jan. 2, Jan. 3. Standard errors are reported, clustered at the state level.

# Gas Tax (Doyle and Samphantharak JPubE 2008)

Regression results: reinstatement

Table : Main results: Tax reinstatement

Dependent variable	Log (retail price)		Log (wholesale price)	
	(1)	(2)	(3)	(4)
<i>C: January tax reinstatement</i>				
Illinois	0.019 (0.035)	-0.001 (0.024)	-0.005 (0.021)	0.029 (0.007)
Post Jan. 1	-0.000 (0.004)	-0.038 (0.004)	-0.020 (0.004)	0.051 (0.002)
IL*Post Jan. 1	0.027 (0.004)	0.036 (0.004)	0.037 (0.004)	-0.014 (0.003)
Observations	7090	7090	7071	7071
R-squared	0.04	0.24	0.39	0.41
Mean of dep. var.	0.303	0.303	0.303	0.303
Controls:				
Wholesale price	No	Yes	Yes	-
ZIP code characteristics	No	No	Yes	Yes

Panel A: Prices observed June 27, June 28, July 5, July 6; Panel B: Prices observed Oct. 26, Oct. 27, Oct. 31, Nov. 1. Panel C: Prices observed Dec. 29, Dec. 30, Jan. 2, Jan. 3. Standard errors are reported, clustered at the state level.

# Gas Tax (Doyle and Samphantharak JPubE 2008)

## Key specification checks

- ▶ Competition across borders:
  - ▶ are neighboring states a good comparison (control) group?
  - ▶ seasonal variation
  - ▶ placebo tests: memorial day, planned repeal, Penn vs NY
- ▶ Neighboring states may have been affected by reforms
  - ▶ stations on borders in treated states: less pressure to reduce prices?
  - ▶ stations on borders in control states: more pressure to reduce prices?
    - ▶ would expect smaller effects of tax changes near borders
  - ▶ estimate DDD-model using with close to border being the third difference
    - ▶ controls for different trends and impacts in border areas
    - ▶ evidence mixed; but effects are mostly smaller near the border

# Gas Tax (Doyle and Samphantharak JPubE 2008)

## Summary

### Main results

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

### Good features:

- ▶ clear graphs, non-parametric, show raw data;
- ▶ multiple “experiments”
- ▶ graphical analysis combined with regression analysis is convincing

### Critique:

- ▶ should show "event study" with Xs in model to see if pre-trends improve
- ▶ short-run estimate only
- ▶ common trends violated?
- ▶ mixed results on border effects (but honest!)