Incidence of Environmental Taxation: Theory

Prof. Richard Sweeney

ECON2277.01, Boston College

Question: Who bears the burden of environmental taxes?

Section 1

Theory

The incidence of (environmental) taxation

- Tax incidence is the study of how a tax effects prices and welfare.
- In the case of a Pigouvian tax, we know that the tax increase social welfare (reduces inefficiency).
- But policymakers still interested in which side of the taxed market bears the burden of the tax.
- Key point: Tax incidence is not a simple accounting exercise. Rather it is an analytical characterization of equilibrium changes.

Example: Gasoline Taxes

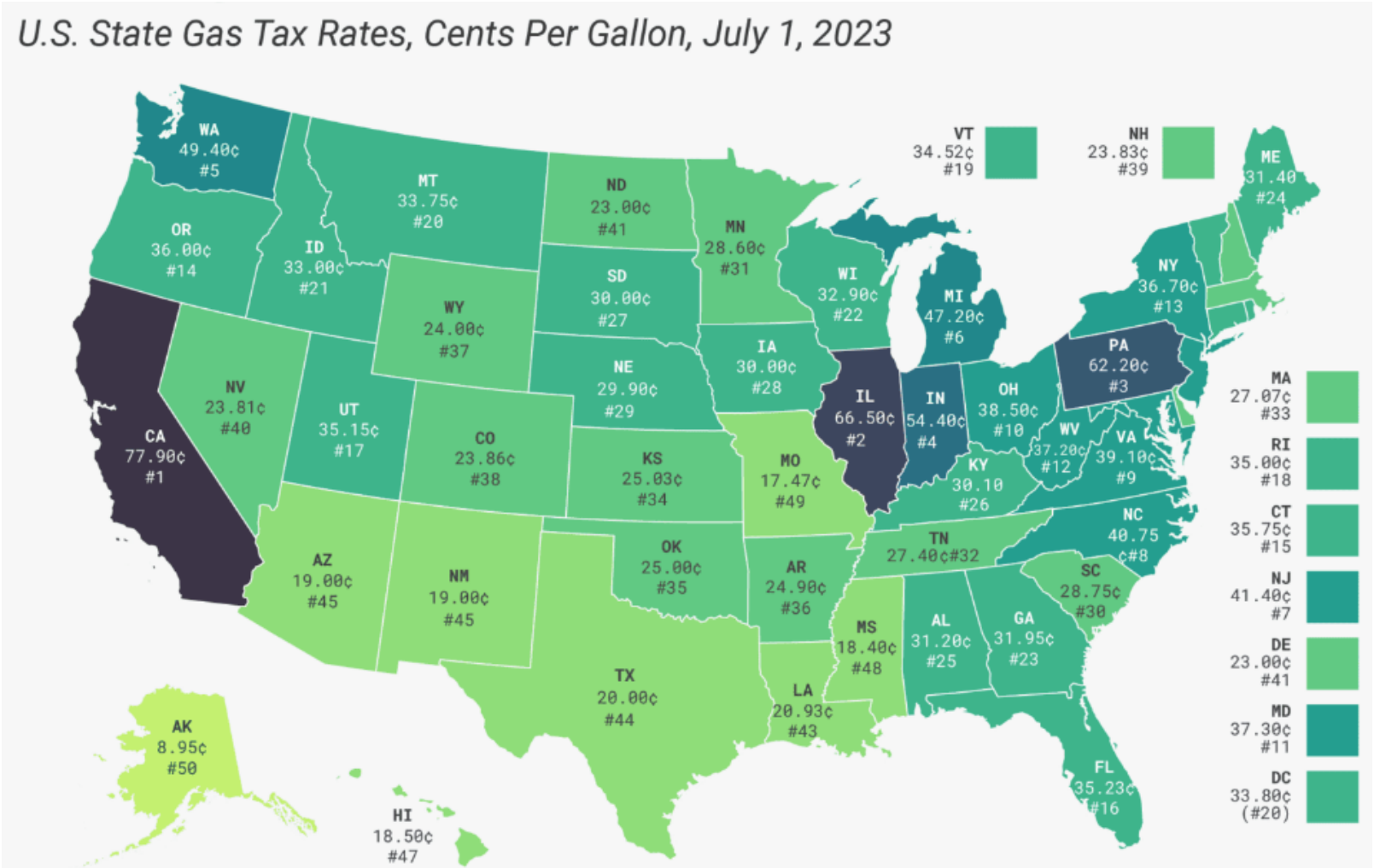
Driving is associated with many externalities

- local pollution (petroleum)
- national security? (petroleum)
- road damage (all driving)
- accident risk (all driving)
- climate change (petroleum)

The economists prescription to deal with these externalities is to tax them.

All told the gas tax should be well above $2/ gallon.

Current State Gasoline Excise Taxes

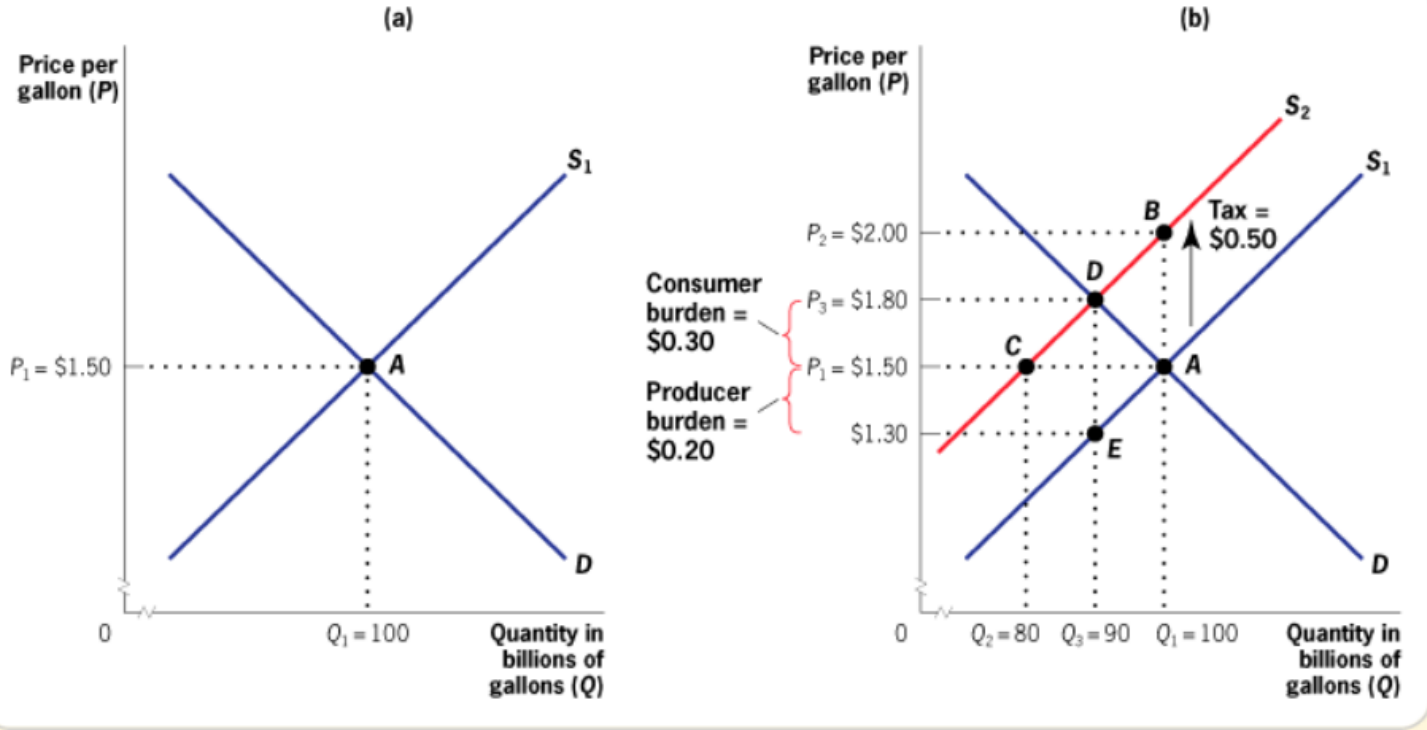


What is the economic incidence of gas taxes?

- Imagine that without taxes, the price at the pump would be $1.50
- Consider a 50 cent excise tax levied on retailers
  - For every wholesale gallon a gas station owner buys, it must pay the state $0.50

Incidence of a tax on retailers

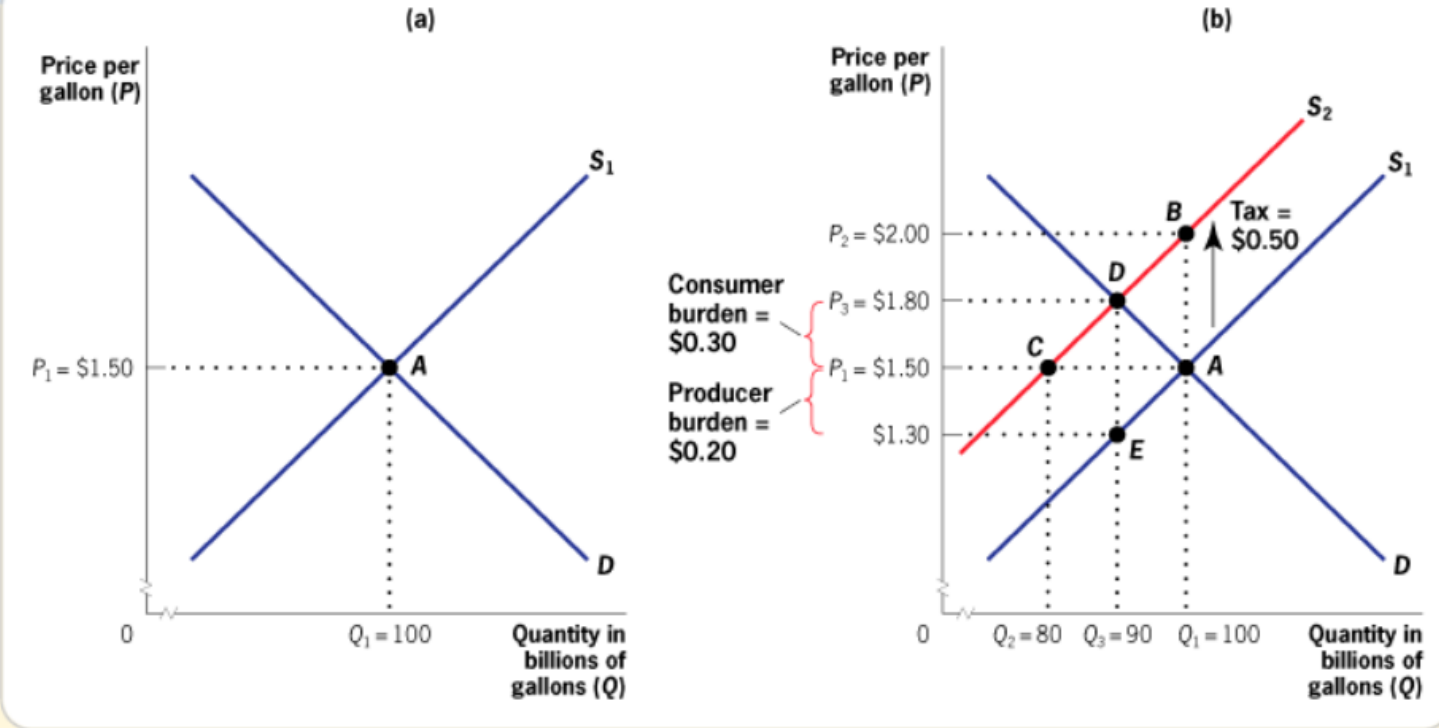
■ FIGURE 19-2



Statutory Burdens Are Not Real Burdens • Panel (a) shows the equilibrium in the gas market before taxation (point *A*). A 50¢ tax levied on gas producers (the statutory burden) in panel (b) leads to a decrease in supply from S_1 to S_2 and to a 30¢ rise in the price of gas from P_1 to P_3 (point *D*). The real burden of the tax is borne primarily by consumers, who pay 30¢ of the tax through higher prices, leaving producers to bear only 20¢ of the tax.

Incidence of a tax on retailers

■ FIGURE 19-2



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Consumer prices increase by 30 cents after a 50 cent tax

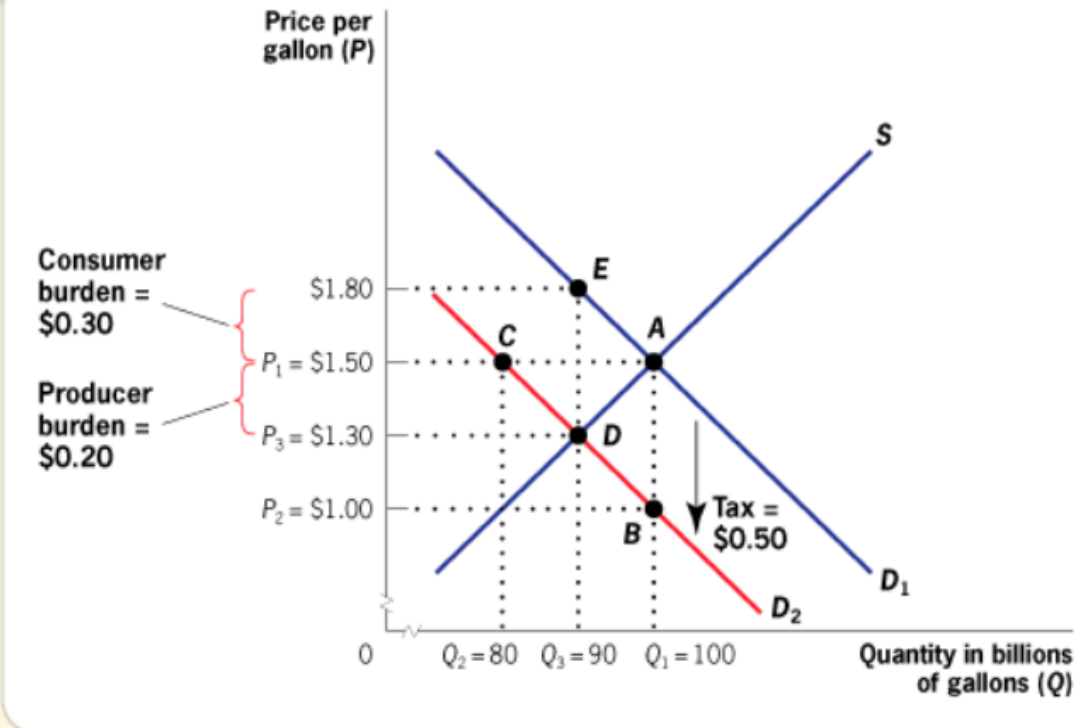
$\Rightarrow$ consumers bear 60% of the economic burden.

What if we taxed drivers instead?

- Now consider a rule change which would shift the statutory burden to consumers
    - Now drivers, not station owners, cut a check to the state
- How would this change the incidence of a 50 cent tax?
- Should consumers oppose this change?

Incidence is the same if we tax drivers

■ FIGURE 19-3



The Side of the Market Is Irrelevant • A 50¢ tax levied on gas consumers (the statutory burden) leads to a decrease in demand from D_1 to D_2 and to a 20¢ fall in the price of gas from P_1 to P_3 (with the market moving from the pre-tax equilibrium at point *A* to the post-tax equilibrium at point *D*). The real burden of the tax is borne primarily by consumers, who pay the 50¢ tax to the government but receive an offsetting price reduction of only 20¢; producers bear that 20¢ of the tax.

What *does* determine incidence?

- In this example, price goes up by \$0.3 after a \$0.5 tax
- This tells us that consumers incur 60% of the economic burden
    - And therefore producers incur 40%
- What determines these proportions?
- The following slides from Emmanual Saez derive an analytical answer.

Partial Equilibrium Tax Incidence

We consider partial equilibrium model with a single good (illustrates well key mechanisms)

Government levies an excise tax on good x

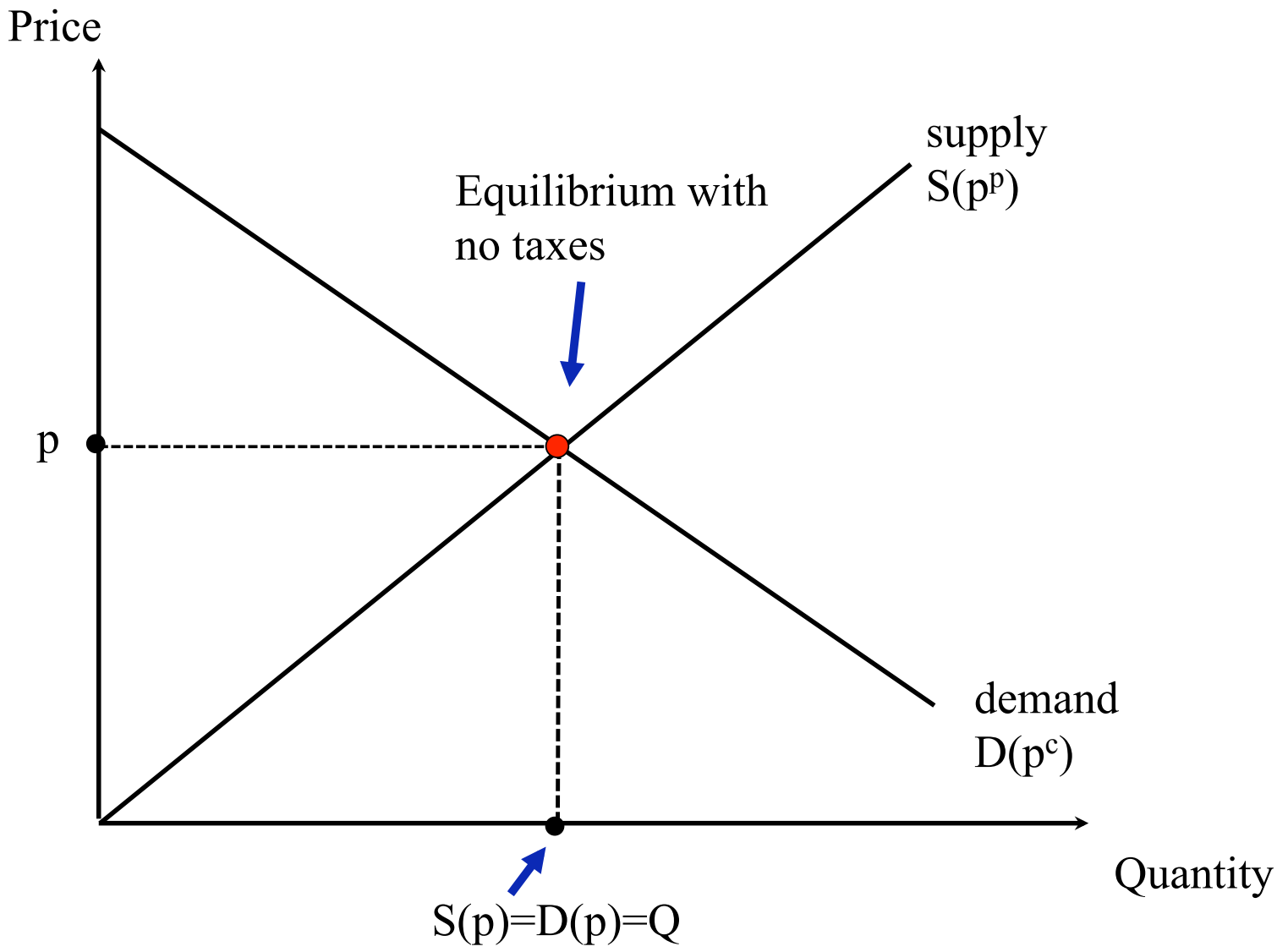
Excise means it is levied on a quantity (gallon, pack, ton, ...). Typically fixed in nominal terms (e.g, \$1 per pack)

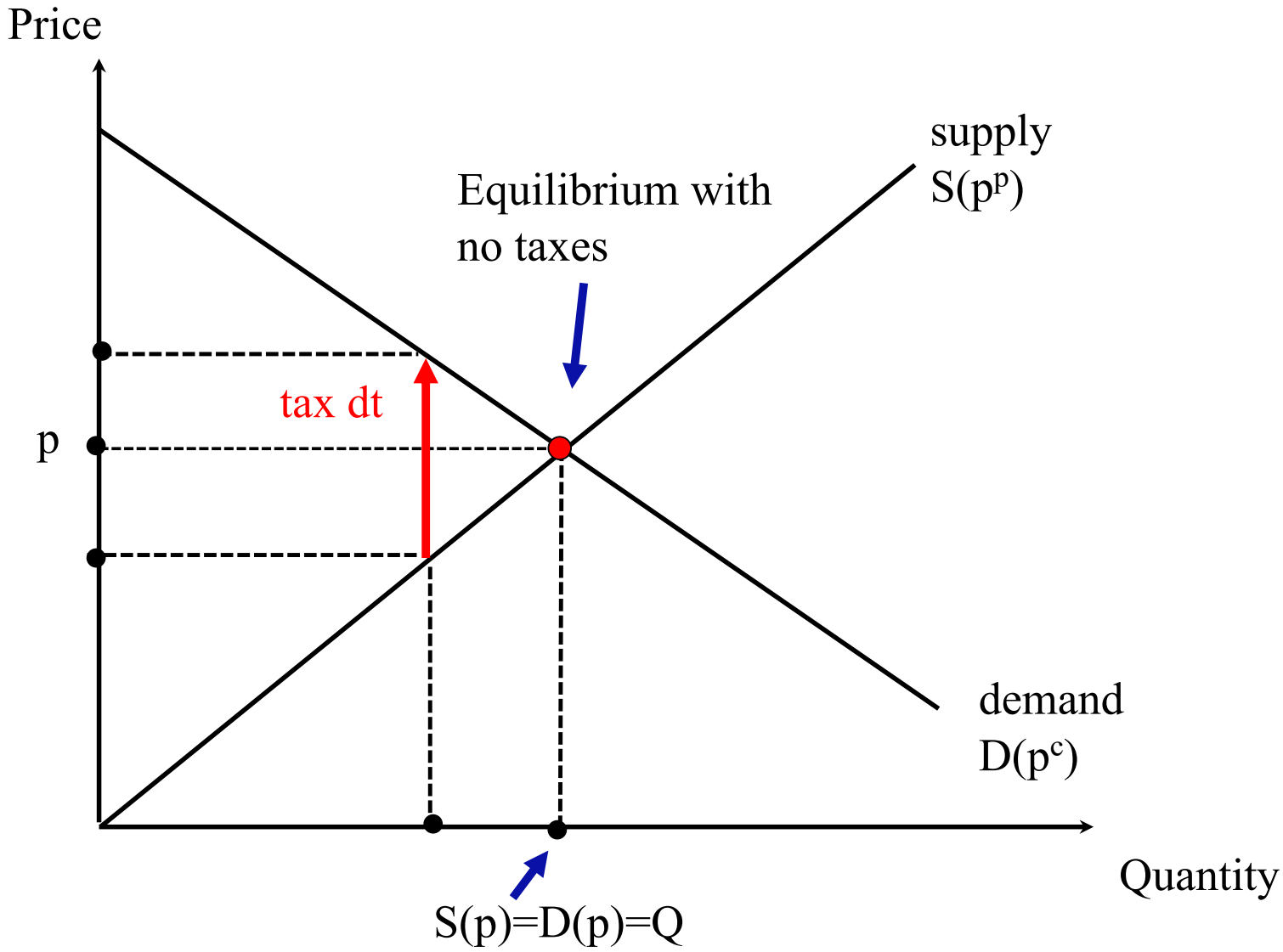
[ad-valorem tax is a fraction of prices (e.g. 5% sales tax)]

Let p denote the pretax price of x (producer price)

Let $p^c = p + dt$ denote the tax inclusive price of x (consumer price) where dt is the tax per unit

We assume that dt is small and trace out the impact dp and dQ on p and Q using calculus


Price
supply
$S(p^p)$
Equilibrium with
no taxes
p
demand
$D(p^c)$
Quantity
S(p)=D(p)=Q


Price
supply
$S(p^p)$
Equilibrium with
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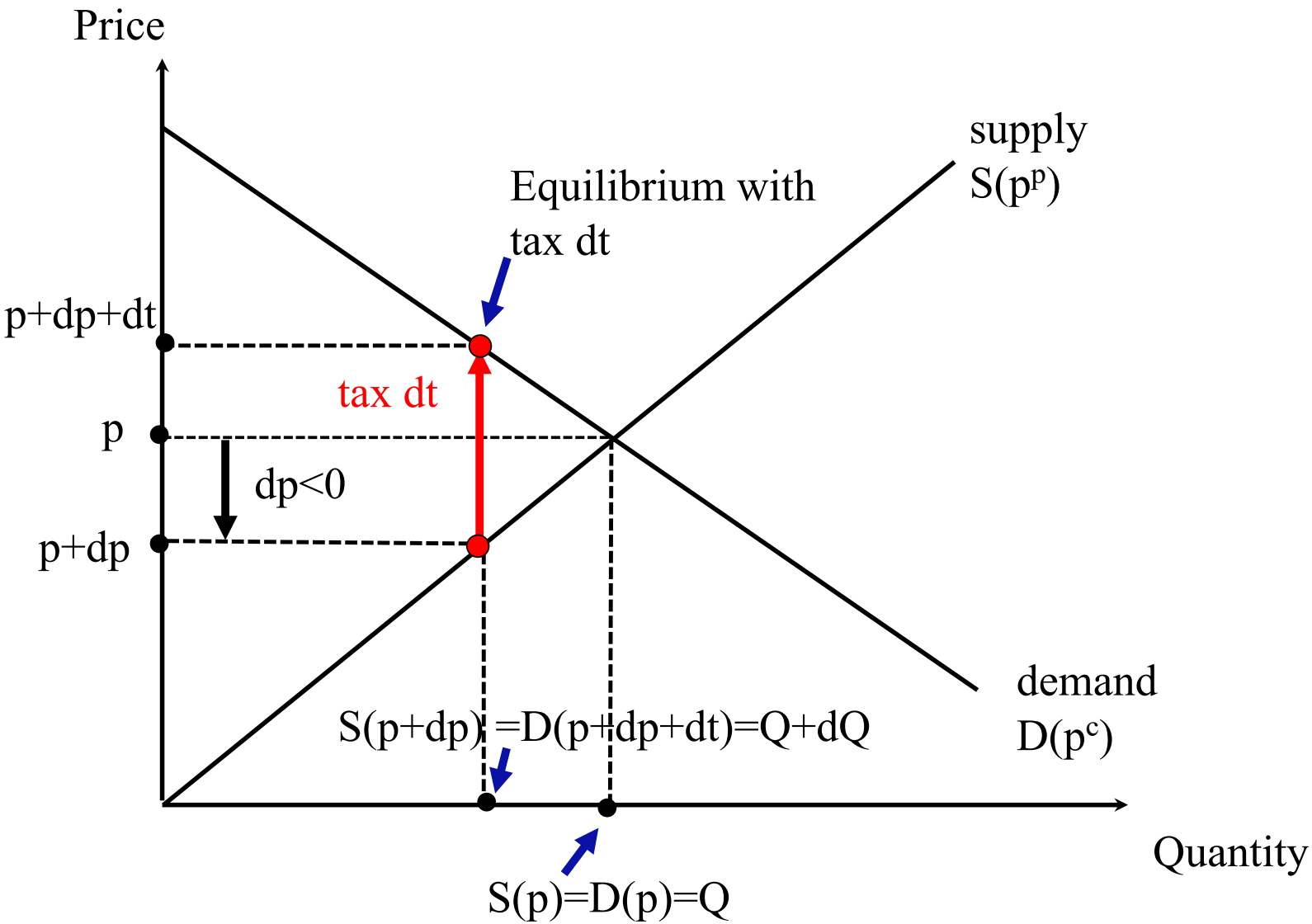
Price
supply
$S(p^p)$
Equilibrium with
tax dt
p+dp+dt
tax dt
p
dp<0
p+dp
demand
$D(p^c)$
S(p+dp) =D(p+dp+dt)=Q+dQ
Quantity
S(p)=D(p)=Q

TAX INCIDENCE

Supply of good x is $S(p)$ increases with producer price $p^p = p$

Demand is $D(p^c)$ decreases with consumer price $p^c = p + dt$

Start from $t = 0$ and no tax equilibrium $S(p) = D(p)$

Effect of a small tax dt on price p:

Change dt generates change dp so that equilibrium holds:

$$S(p + dp) = D(p + dp + dt) \Rightarrow$$

$$S(p) + S'(p)dp = D(p) + D'(p)(dp + dt) \Rightarrow$$

$$S'(p)dp = D'(p)(dp + dt) \Rightarrow$$

$$\frac{dp}{dt} = \frac{D'(p)}{S'(p) - D'(p)}$$

TAX INCIDENCE FOR SMALL TAX dt

Elasticities useful in economics because they are unit free

Elasticity: percentage change in quantity when price changes by one percent

$\varepsilon_D = \frac{p^c}{D}\frac{dD}{dp^c} = \frac{p^c D'(p^c)}{D(p^c)} < 0$ denotes the price elasticity of demand

$\varepsilon_S = \frac{p}{S}\frac{dS}{dp} = \frac{pS'(p)}{S(p)} > 0$ denotes the price elasticity of supply

$$\frac{dp}{dt} = \frac{D'(p)}{S'(p) - D'(p)} = \frac{pD'(p)/D(p)}{pS'(p)/S(p) - pD'(p)/D(p)} = \frac{\varepsilon_D}{\varepsilon_S - \varepsilon_D}$$

$$-1 \leq \frac{dp}{dt} \leq 0 \quad \text{and} \quad 0 \leq \frac{dp^c}{dt} = 1 + \frac{dp}{dt} \leq 1$$

Tax incidence depends on elasticities

Buyers' share (increase in price paid per unit of t):

$$\frac{dP^c}{dt} = \frac{\varepsilon_S}{\varepsilon_S - \varepsilon_D} = \frac{\varepsilon_S}{\varepsilon_S + |\varepsilon_D|}. \quad (1)$$

Sellers' share (decrease in net price received per unit of t):

$$-\frac{dP}{dt} = \frac{-\varepsilon_D}{\varepsilon_S - \varepsilon_D} = \frac{|\varepsilon_D|}{\varepsilon_S + |\varepsilon_D|}. \quad (2)$$

Consumers bear full burden if:
– Perfectly inelastic demand: $\epsilon_D = 0$
– Perfectly elastic supply $\epsilon_S = \infty$

Producers bear full burden if:
– Perfectly inelastic supply: $\epsilon_s = 0$
– Perfectly elastic demand $\epsilon_D = -\infty$

Inelastic factors bear taxes

Perfectly Inelastic Demand

■ FIGURE 19-4

Inelastic Factors Bear Taxes • A tax on producers of an inelastically demanded good is fully reflected in increased prices, so consumers bear the full tax.

Elastic factors avoid them

Perfectly Elastic Demand

■ FIGURE 19-5

Elastic Factors Avoid Taxes • A tax on producers of a perfectly elastically demanded good cannot be passed along to consumers through an increase in prices, so producers bear the full burden of the tax.

Inelastic factors bear taxes; Elastic factors avoid

Supply Elasticities

■ FIGURE 19-6

Elasticity of Supply Also Matters • A tax on producers of an inelastically supplied good, as in panel (a), leads to a very small rise in prices, so producers bear most of the burden of the tax. An equal-sized tax on producers of an elastically supplied good, as in panel (b), leads to a large rise in prices, so producers bear little of the burden of the tax (and consumers bear most of the burden).

What determines these elasticities?

Demand:

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Demand:

- Availability of substitutes
- How “essential” is a good

Supply:

What determines these elasticities?

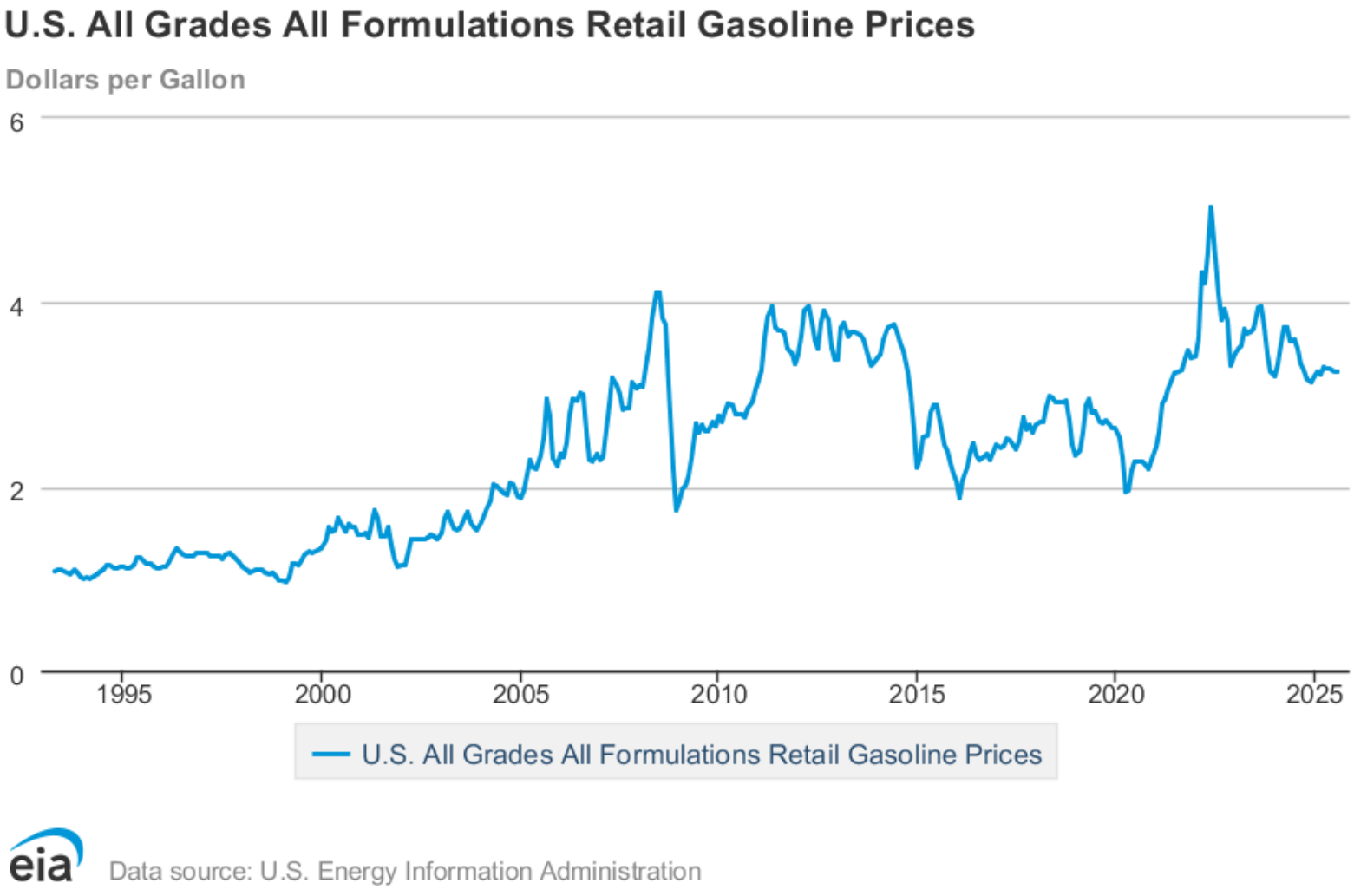
Demand:

- Availability of substitutes
- How “essential” is a good

Supply:

- Availability of inputs
- Capacity constraints

In the short run, both supply and demand are inelastic. This is why prices are so volatile.



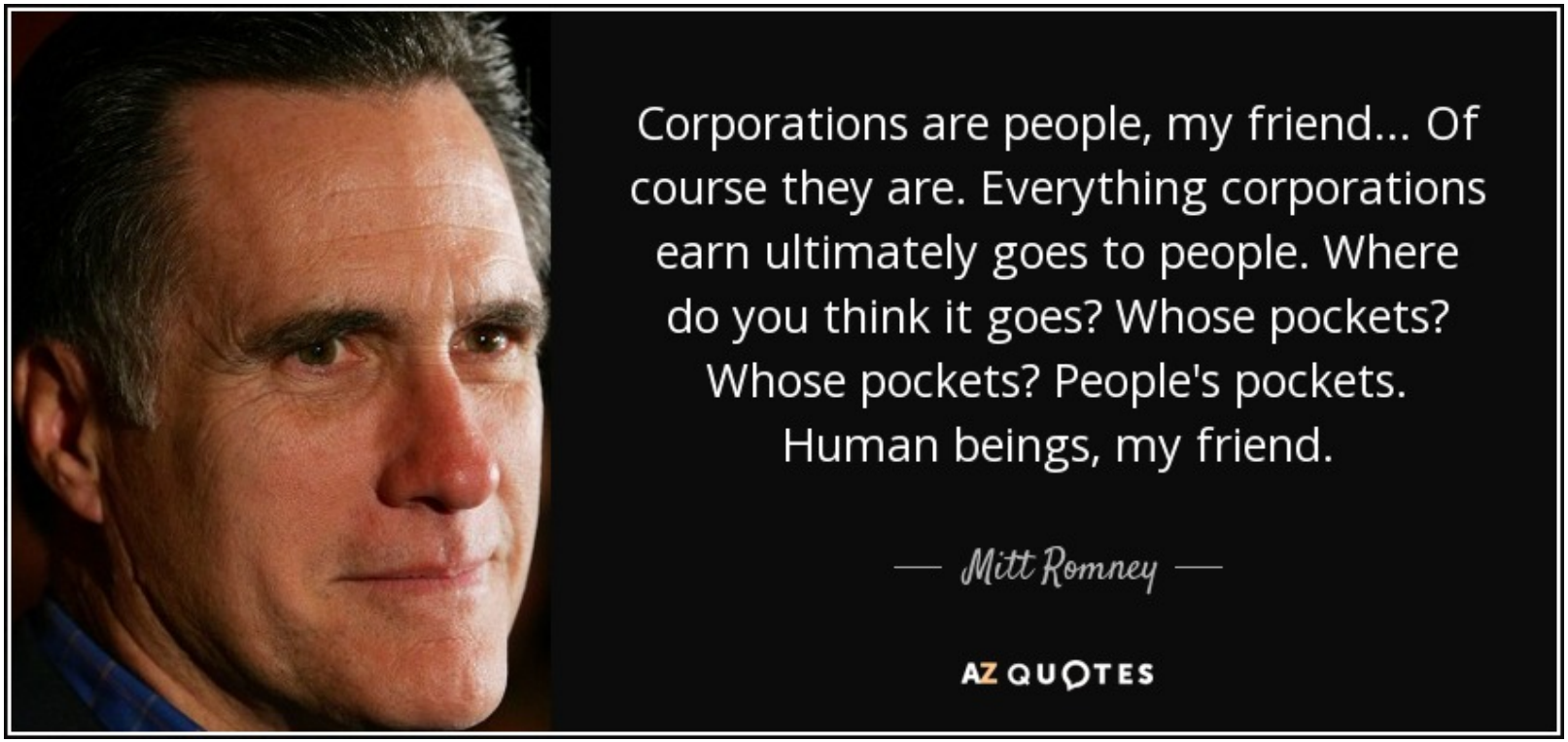
What about the long run?

Are things more or less elastic?

What about the long run?

Are things more or less elastic?

- In general, more elastic
- Demand: Divers buy different cars
- Supply: Can open up new oil fields


Corporations are people, my friend... Of course they are. Everything corporations earn ultimately goes to people. Where do you think it goes? Whose pockets? Whose pockets? People's pockets. Human beings, my friend.
— Mitt Romney —
AZ QUOTES

Ultimately, costs are borne by individuals

Either consumers, taxpayers, or shareholders

Tax and Stock Ownership Inputs

Decile	Marginal Tax Rate	Average Tax Rate	Stock Ownership
1	-15%	4%	0.80%
2	3%	4%	0.50%
3	11%	10%	0.90%
4	16%	10%	1.70%
5	17%	14%	2.40%
6	19%	14%	4.20%
7	22%	17%	5.70%
8	27%	17%	7.00%
9	30%	23%	12.10%
10	36%	27%	64.70%

Sources: Supporting analysis for Cogressional Budget Office (2005); Department of Treasury (2007)

Wrapup on incidence theory

- Natural to think government can dictate who bears the burden of regulation.
- Result 1: Statutory incidence does not determine economic incidence.
  - In a market economy, costs or regulations on one side will eventually affect prices and quantity demanded. And these determine economic welfare.
- Result 2: Economic incidence depends of elasticities of supply and demand.
  - Relatively inelastic factors bear more of the tax burden.
- Note: This assumes perfect competition.

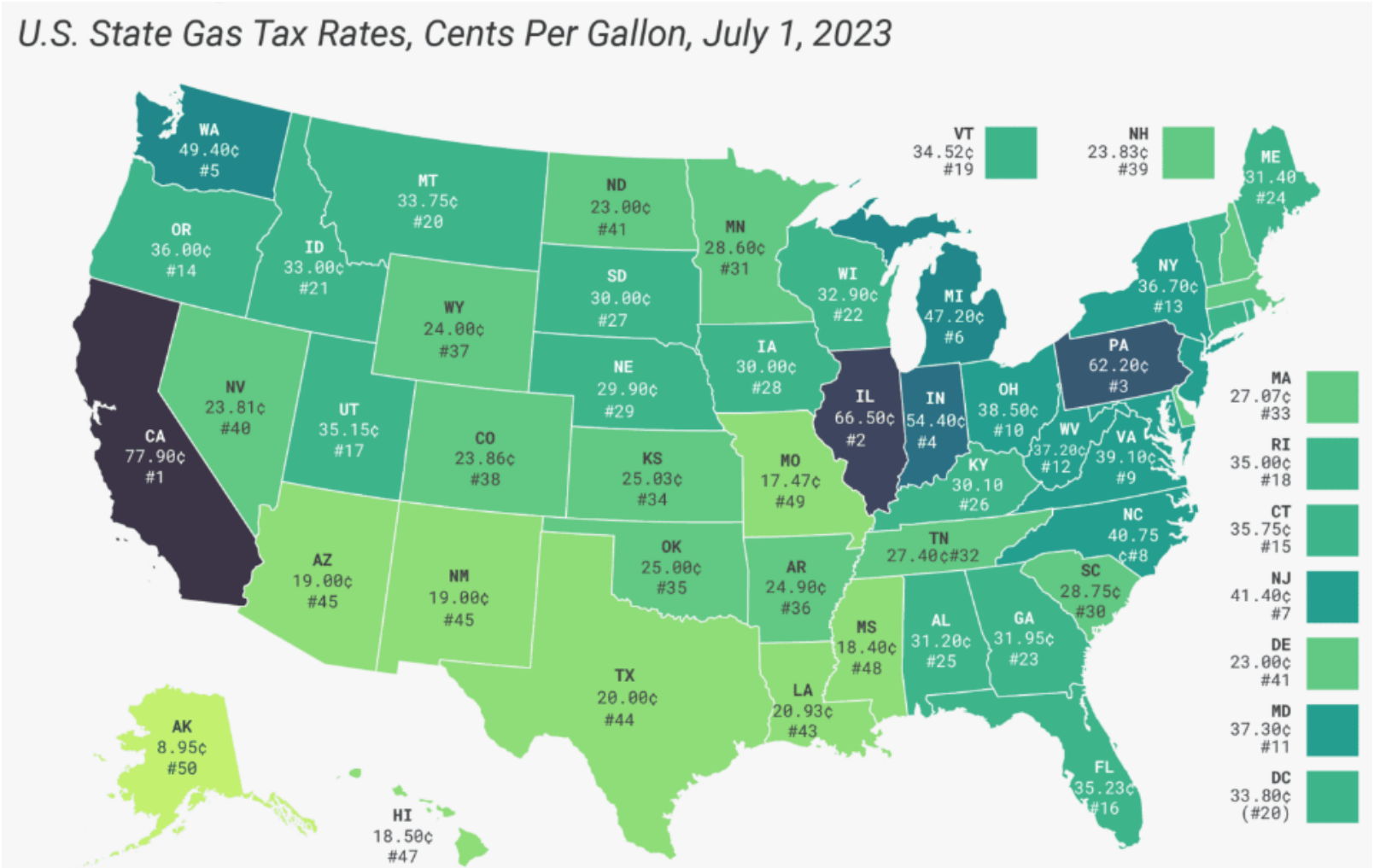
Section 2

Empirical Evidence

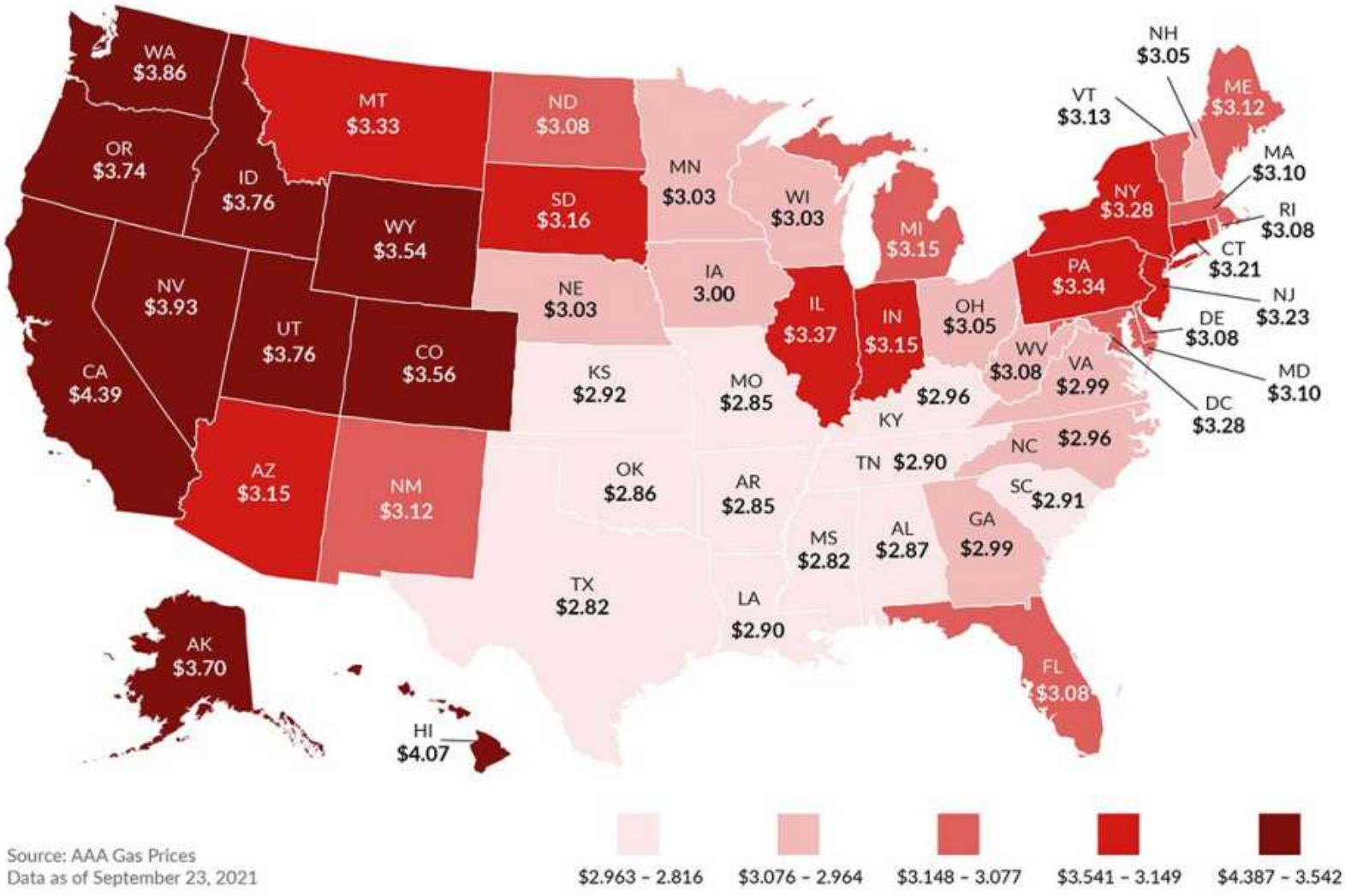
Empirical evidence on gas tax incidence

- If we know the elasticities (and assume perfect competition), we can predict incidence.
- Often we don't know these though... (this used to be covered)
- Instead often try to estimate the impact of a tax change on prices.

Taxes vary by state



And prices vary by state



Can we just regress prices on taxes?

$$P_s^c = \alpha + \beta \text{Tax}_s + \varepsilon_s$$

- What are some concerns with a causal interpretation of this β in regression?

Can we just regress prices on taxes?

$$P_s^c = \alpha + \beta \text{Tax}_s + \varepsilon_s$$

- What are some concerns with a causal interpretation of this β in regression?
- Omitted variable bias:
  1. Are there other things that differ across states that cause gas prices to be higher / lower? (ahem, New Jersey?)
  2. Are any of those things correlated with gas taxes? (see previous map)
- If answer to those things is yes, then OVB $\Rightarrow \hat{\beta}$ biased.

How does this paper try to get around this?

SEVIER

Journal of Public Economics 92 (2008) 869–884

JOURNAL OF PUBLIC ECONOMICS

www.elsevier.com/locate/econbase

$2.00 Gas! Studying the effects of a gas tax moratorium☆

Joseph J. Doyle Jr. [a,b,*], Krislert Samphantharak[c,*]

[a] *MIT Sloan School of Management, USA*
[b] *NBER, USA*
[c] *University of California, San Diego - Graduate School of International Relations and Pacific Studies, USA*

What is the empirical strategy of this paper?

Gas Tax: Doyle & Samphantharak (JPubE 2008)

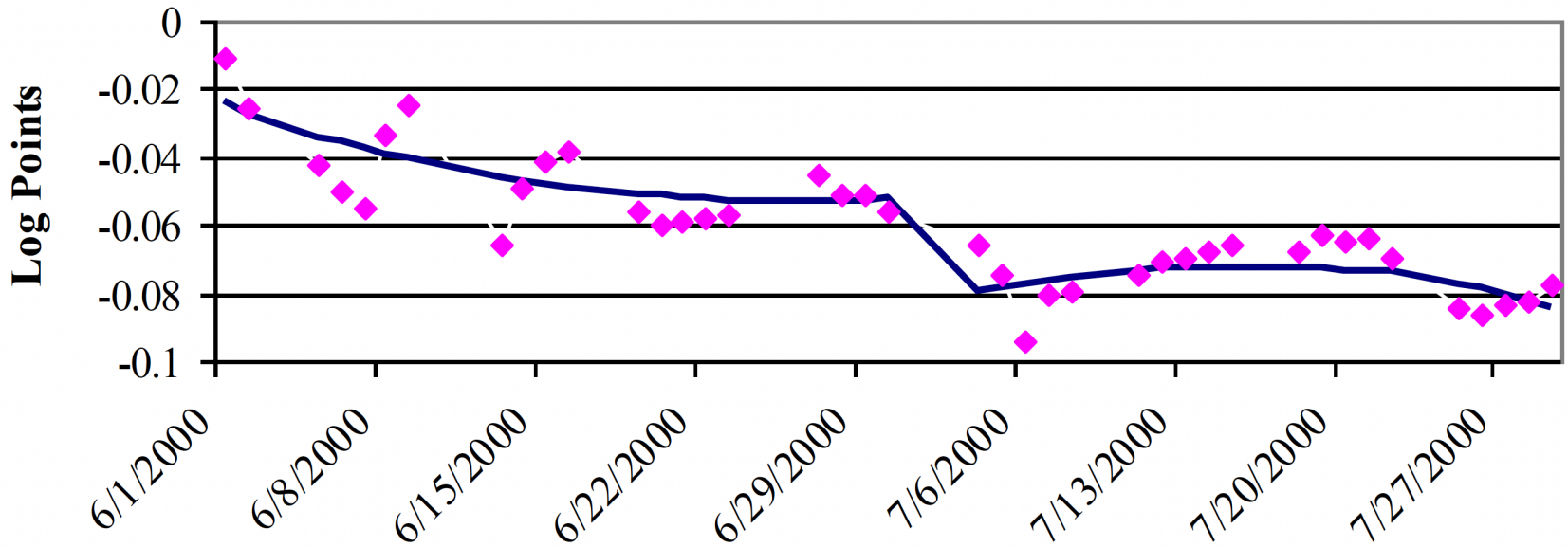
- Question: Who bears the burden of the gas *sales* tax?
- Appealing features:
  - Salient, high-attention tax change
  - Fall (repeal) and rise (reinstatement) events
  - Governor action allowed quick policy changes
- Note: This is the *sales* (ad valorem) tax, not the excise tax.

Policy Variation: Timing & Magnitudes

- Setting: 2000 price spike $\Rightarrow$ temporary sales tax holidays in IN and IL
  - Note this is a *sales* tax, not an excise tax
- Indiana (IN): suspend 5% sales tax July 1;
  - reinstate Oct 30
- Illinois (IL): suspend 5% sales tax July 1;
  - reinstate Dec 31
- Tax base: $\sim 90\%$ of posted price (IL), $\sim 80\%$ (IN)
  - Full shifting to consumers would be: IL $\approx 4.5\%$ price change; IN $\approx 4\%$

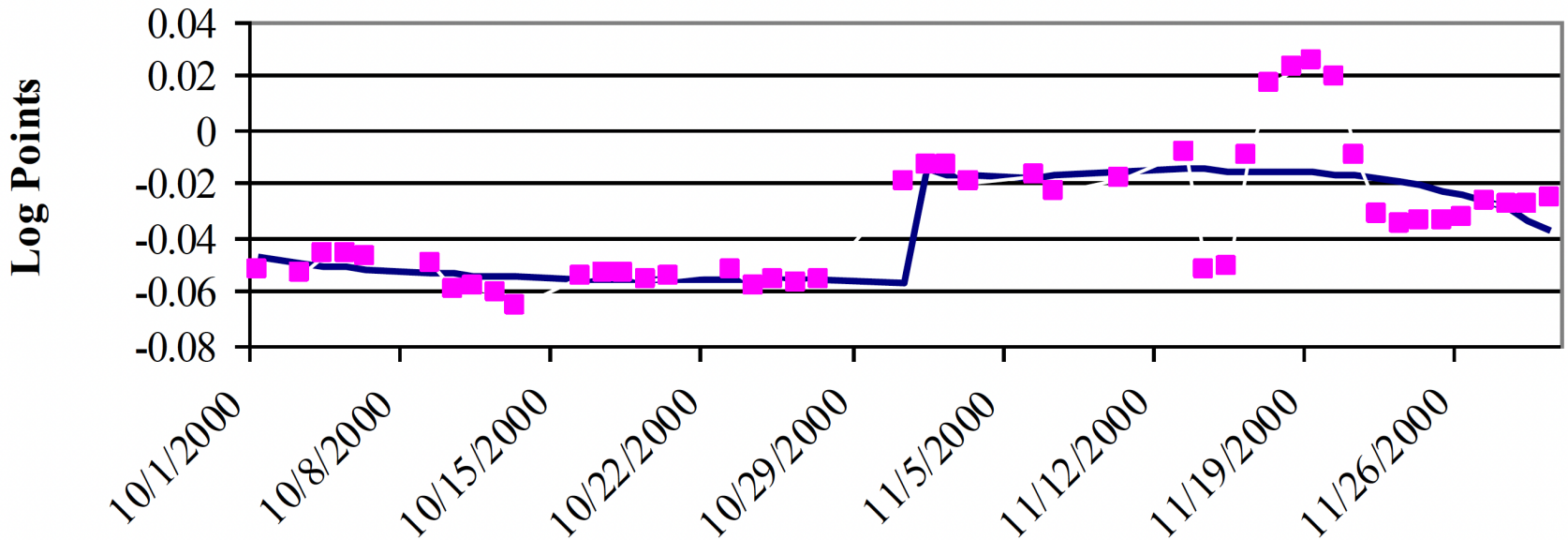
Graphical Evidence: Price July 2000 Repeal

Figure 2A: Summer 2000 Difference in Log Gas Prices
IL/IN vs. Neighboring States: MI, OH, MO, IA, WI



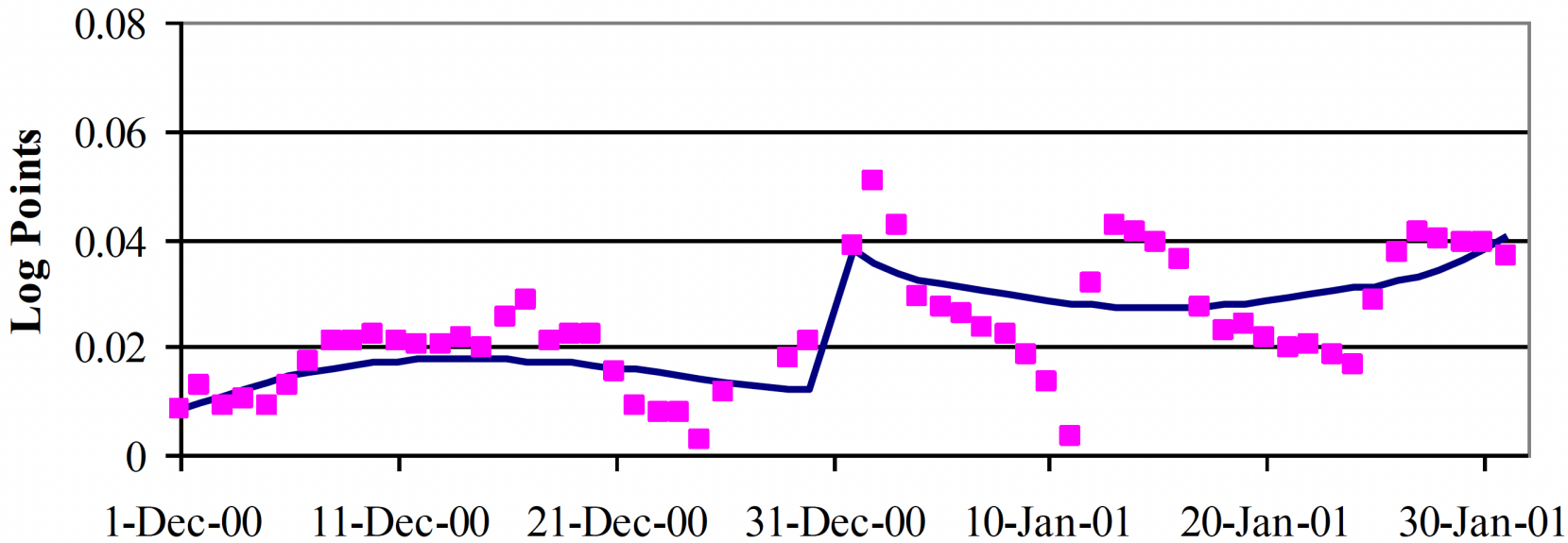
Graphical Evidence: Price Oct Reinstatement (IN only)

Figure 2B: Fall 2000 Difference in Log Gas Prices
IN vs. Neighboring States: MI, OH, IL



Graphical Evidence: Price Jan Reinstatement (IL only)

Figure 2C: Winter 2000/2001 Difference in Log Gas Prices
IL vs. Neighboring States: MO, IA, WI, IN



Empirical Strategy & DD Specification

- Difference-in-differences using neighboring states (MI, OH, MO, IA, WI)
- Flexible event-time graphs, then regression:

$$\begin{aligned}\ln(\text{RetailPrice}_{sbt}) = \gamma_0 &+ \gamma_1(\text{IL/IN}) + \gamma_2\text{Post} \\ &+ \gamma_3[(\text{IL/IN}) \times \text{Post}] \\ &+ \gamma_4 \ln(\text{Wholesale}) + \gamma_5 X_s + \delta_b + \varepsilon_{sbt}\end{aligned}$$

- γ_3 measures incidence (pass-through to retail prices)

Regression Results: July Repeal (Panel A)

A: July Tax Repeal

Dependent Variable:	Log(Retail Price)		
	(1)	(2)	(3)
Illinois or Indiana	-0.048	-0.013	-0.014
	(0.038)	(0.025)	(0.021)
Post July 1	-0.052	0.029	0.025
	(0.007)	(0.013)	(0.015)
(IL or IN)*Post July 1	-0.035	-0.029	-0.029
	(0.007)	(0.008)	(0.008)
Observations	29675	29675	29433
R-Squared	0.23	0.60	0.64
Mean of Dep. Var.	0.560	0.560	0.560
Controls:			
Wholesale Price	No	Yes	Yes
ZIP Codes Characteristics & Brand	No	No	Yes

- $\approx 70\%$ of tax cut passed through to consumers.

Regression Results: Reinstatements

B: October Tax Reinstatement	
Dependent Variable:	Log(Retail Price)
	(3)
Indiana	-0.053
	(0.007)
Post Oct. 31	-0.009
	(0.006)
IN*Post Oct. 31	0.040
	(0.006)
Observations	21884
R-Squared	0.26
Mean of Dep. Var.	0.456

C: January Tax Reinstatement	
Dependent Variable:	Log(Retail Price)
	(3)
Illinois	-0.005
	(0.021)
Post Jan. 1	-0.020
	(0.004)
IL*Post Jan. 1	0.037
	(0.004)
Observations	7071
R-Squared	0.39
Mean of Dep. Var.	0.303

Regression Results: Reinstatements

B: October Tax Reinstatement		C: January Tax Reinstatement	
Dependent Variable:	Log(Retail Price)	Dependent Variable:	Log(Retail Price)
	(3)		(3)
Indiana	-0.053	Illinois	-0.005
	(0.007)		(0.021)
Post Oct. 31	-0.009	Post Jan. 1	-0.020
	(0.006)		(0.004)
IN*Post Oct. 31	0.040	IL*Post Jan. 1	0.037
	(0.006)		(0.004)
Observations	21884	Observations	7071
R-Squared	0.26	R-Squared	0.39
Mean of Dep. Var.	0.456	Mean of Dep. Var.	0.303

- Reinstatements show 80–100% pass-through to consumers.
- Matches a “rockets and feathers” pattern: prices rise quickly but fall slowly in response to cost changes.

Pass-Through & Elasticities

- Estimated pass-through $\approx 70\%$ for repeal episodes.
- "buyer's share" from incidence theory above.

$$0.7 = \frac{dP^c}{dt} = \frac{\varepsilon_S}{\varepsilon_S + |\varepsilon_D|}. \tag{3}$$

- Estimates of demand elasticity for gas -0.05 to -0.25
- This implies supply elasticity 0.1 to 0.6

Empirical evidence: fracking boom

PASS-THROUGH OF OWN AND RIVAL COST SHOCKS: EVIDENCE FROM THE U.S. FRACKING BOOM

Erich Muehlegger and Richard L. Sweeney*

Abstract—In imperfectly competitive settings, a firm's price depends on its own costs as well as those of its competitors. We demonstrate that this has important implications for the estimation and interpretation of pass-through. Leveraging a large input cost shock resulting from the fracking boom, we isolate price responses to firm-specific, regional, and industry-wide input cost shocks in the U.S. oil refining industry. The pass-through of these components varies from near zero to full pass-through, reconciling seemingly disparate results from the literature. We illustrate the policy implications of rival cost pass-through in the context of a tax on refinery carbon emissions.

changes invalidates them as a control group.[1] Second, when using pass-through for policy prediction, the identifying variation used in estimation must match the policy application. For example, a pass-through estimate identified from firm-level cost or tax shocks may substantially underestimate the price impact of an industry-wide policy change.

We demonstrate these points empirically by studying the response of prices in the U.S. oil refining industry to large in-

What is this paper about? How is it different from the previous one?

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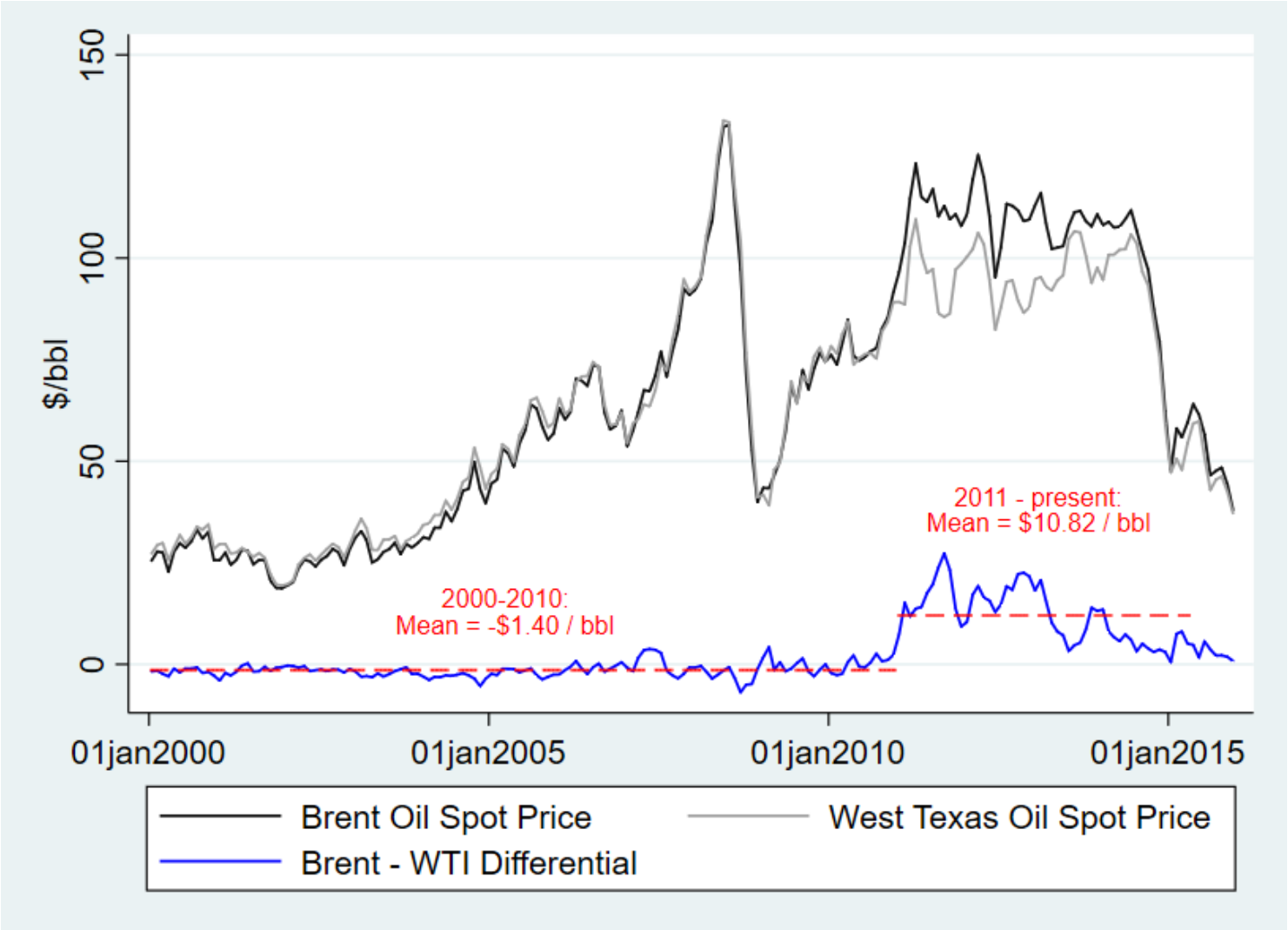
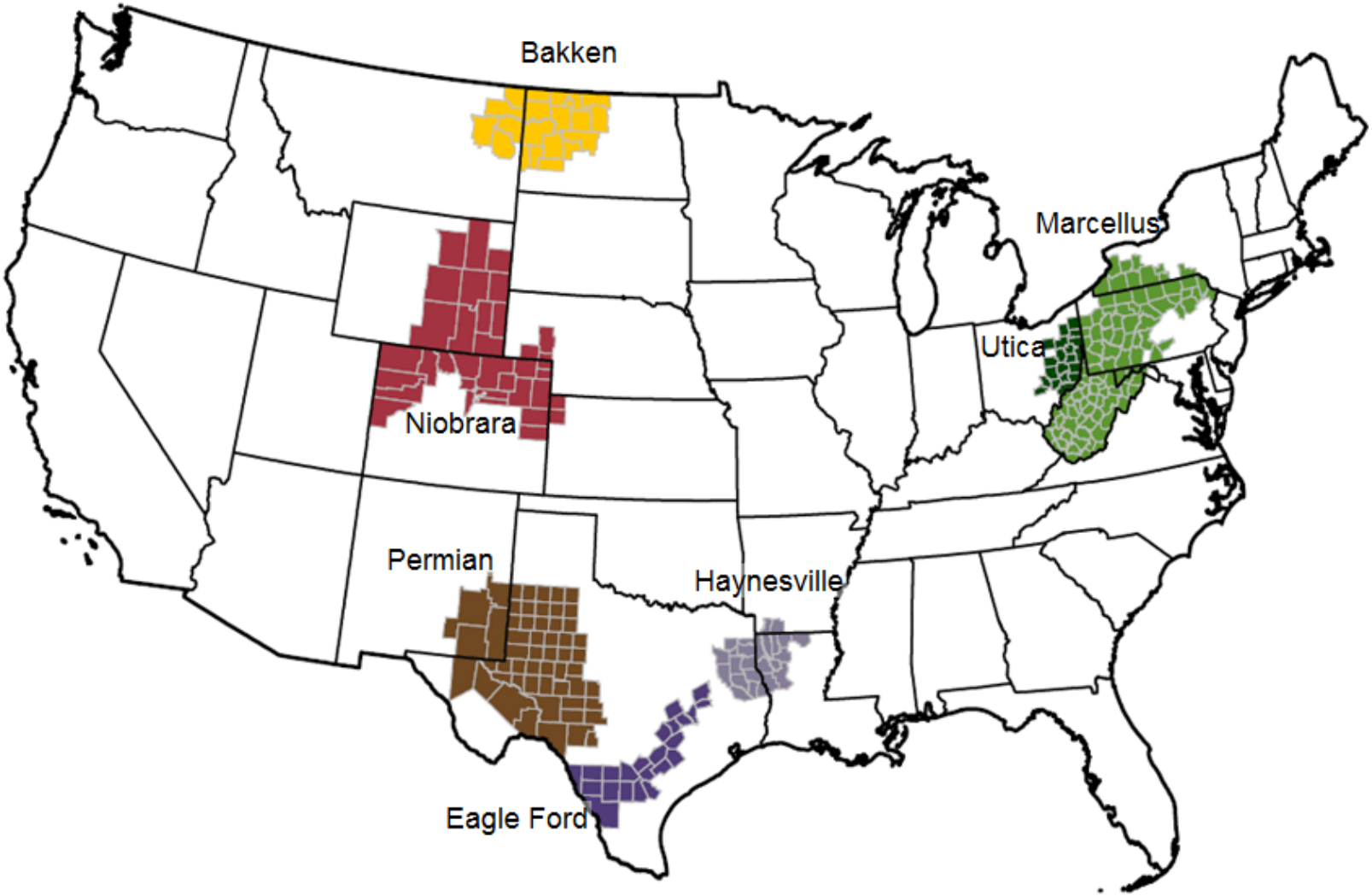
1. Allow for imperfect competition
2. Use changes in costs (not taxes) to estimate pass-through

Fracking caused an unprecedented divergence from global crude prices

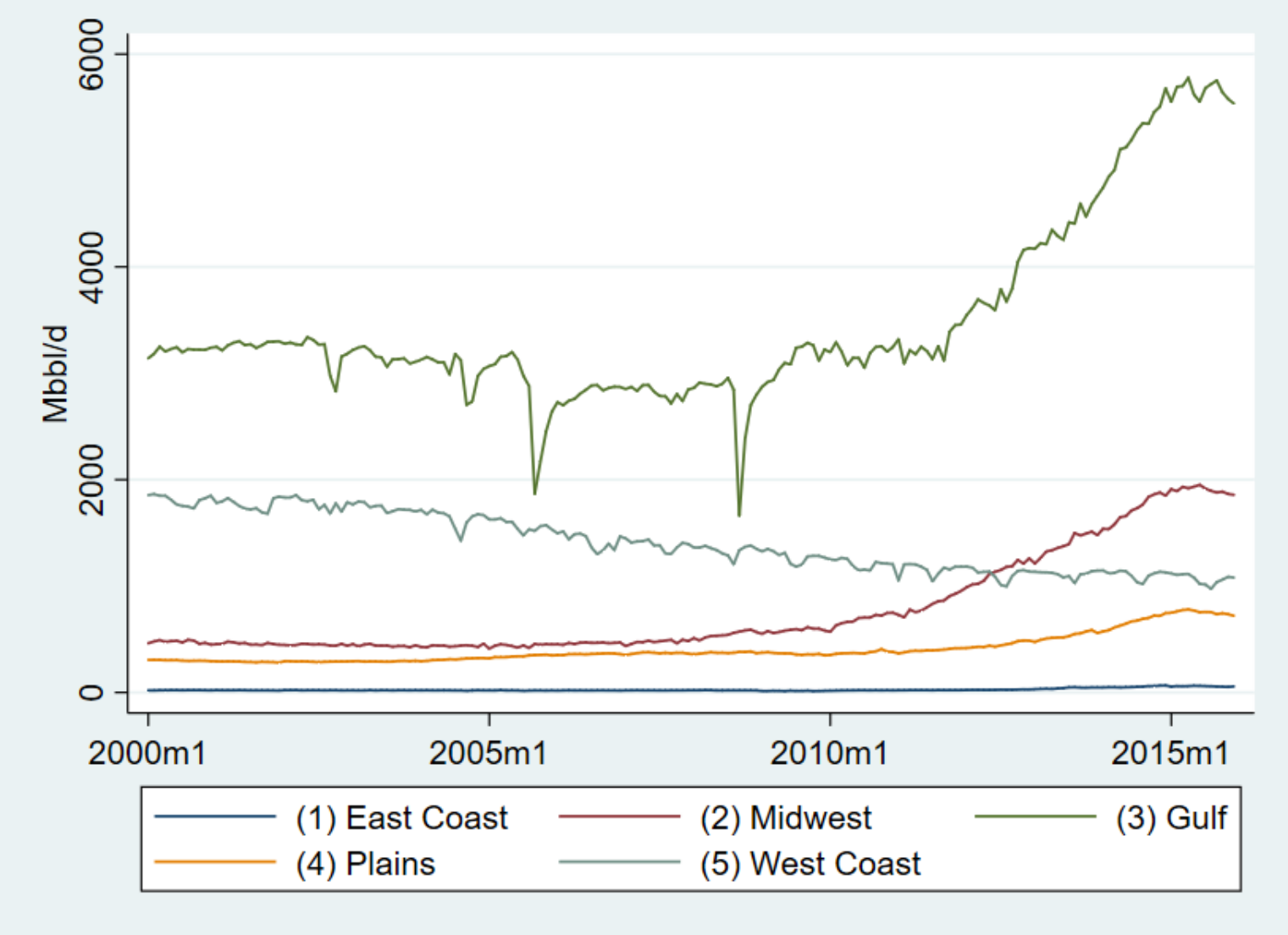


Export ban in effect until 2015.

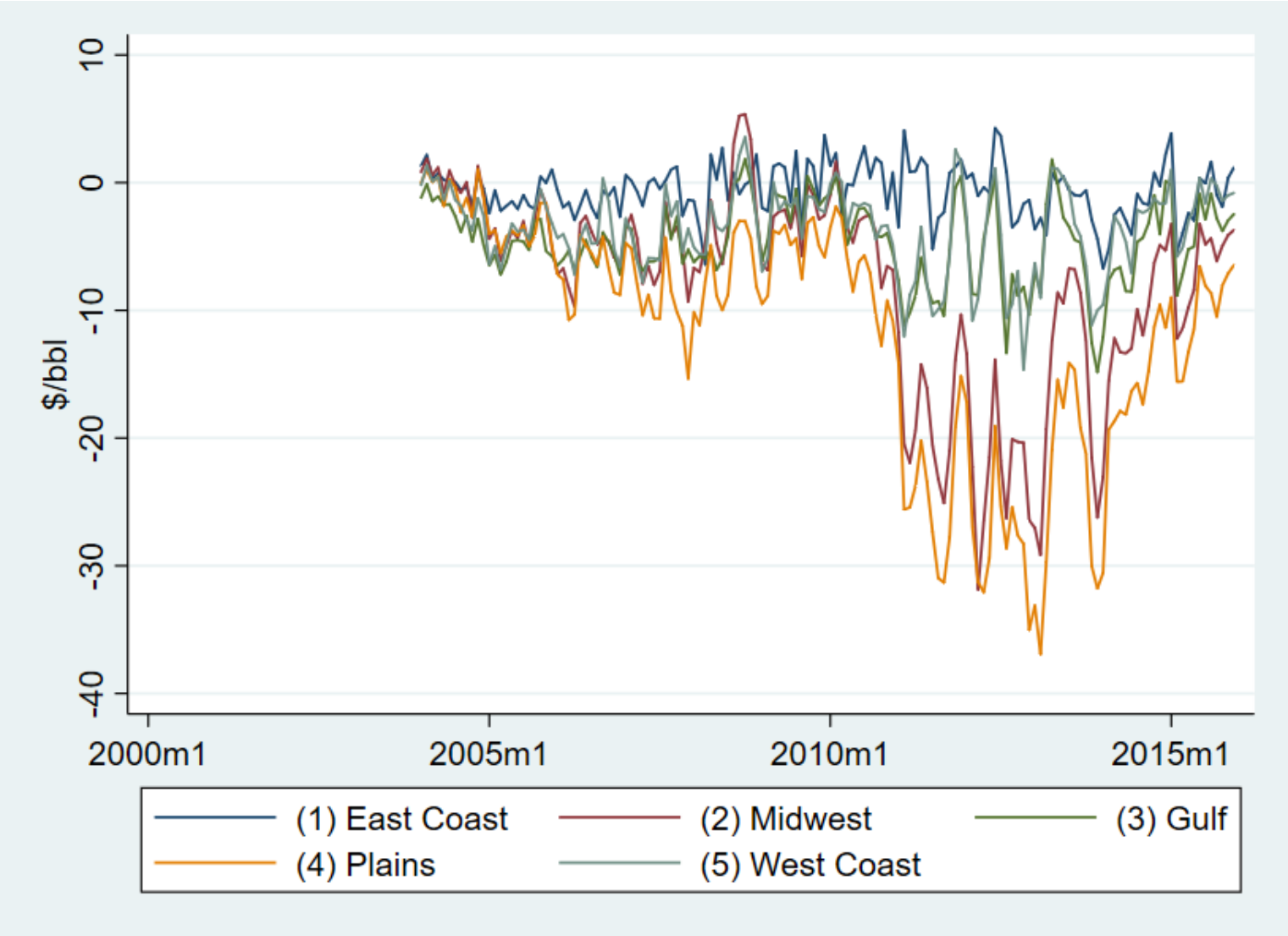
Location of major US shale oil plays



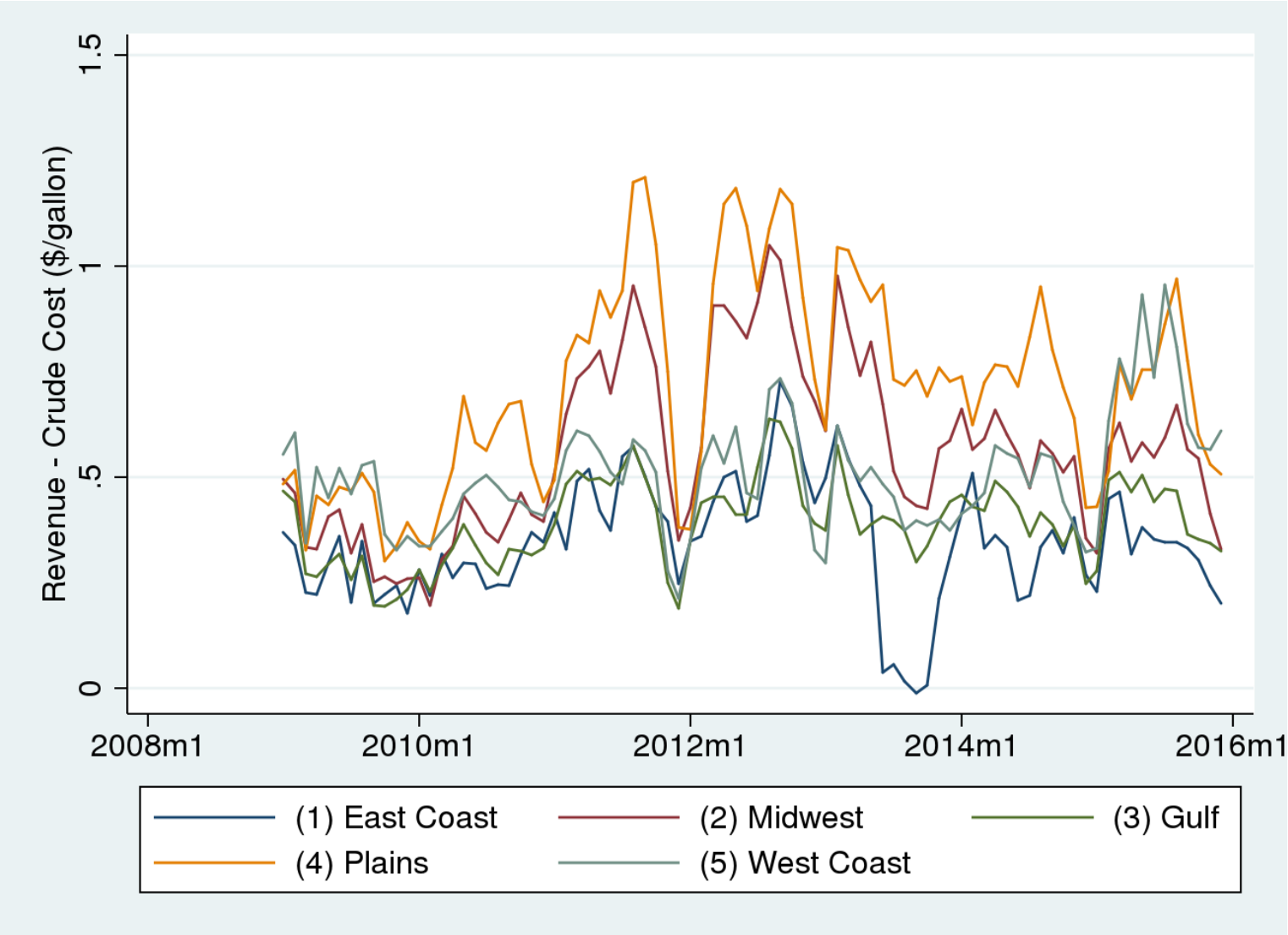
Biggest increases in were in ND (Plains) and TX (Gulf Coast)



Pipeline constraints caused crude costs to diverge within the US



We estimate how much of those cost reductions were passed on to consumers



Accounting for imperfect competition

- Basic incidence theory assumes perfect competition
  - This means: firms are price takers, and price equals marginal cost
- In reality, gasoline suppliers have some market power
  - The price they charge can exceed marginal cost
- In this environment, the price a firm charges depends on both it's own costs as well it's competitors' costs
- Implication: Cost changes (or taxes) affect the prices of all firms in the market (even those not directly effected)
  - This applies to tariffs as well...

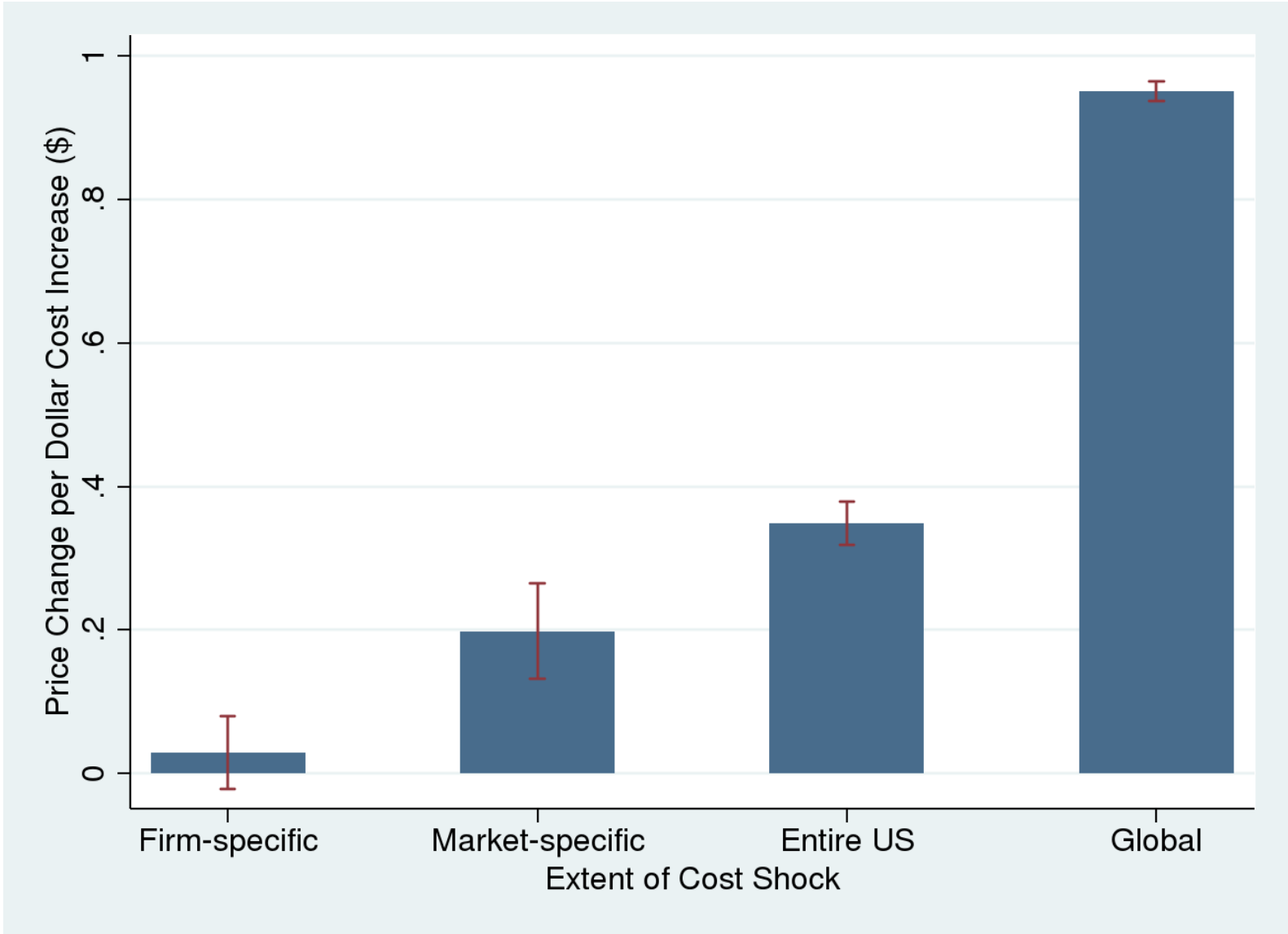
State regression results

$$\text{Price}_{st} = \alpha + \beta^{Own}\text{Own Cost}_{st} + \beta^{Rival}\text{Rival Cost}_{st} + \mu_s + \eta_t + \varepsilon_{st}$$

TABLE 2.—COMPETITION MEASURE RESULTS

	(1)	(2)	(3)	(4)
a. State-Level Results				
Own	0.0447***	0.0485***	0.0606**	0.0704***
	(0.0133)	(0.0134)	(0.0255)	(0.0252)
Rival	0.282***	0.128***	0.146***	0.0357
	(0.0164)	(0.0214)	(0.0299)	(0.0387)
Fringe		0.159***		0.112***
		(0.0220)		(0.0357)
Brent spot	0.625***	0.617***	0.732***	0.722***
	(0.0113)	(0.0101)	(0.0124)	(0.0105)
Rival measure		Avg		Avg
IV			Yes	Yes
fstat			4,651	3,137
N	71,570	71,529	71,570	71,529

Incidence depends on scope of the cost shock



What does this tell us about the incidence of a carbon tax?

- Over 20% of well-to-wheel gasoline emissions prior to the pump
  - Roughly 10% from refining
- Annual facility level emissions available through EPA GHGRP
- Second highest ranked sector in terms of GHG emissions per facility (behind Power Plant Sector)
  - average of 1.22 MMT CO2e
- 145 facilities ~ 3% total US GHG emissions

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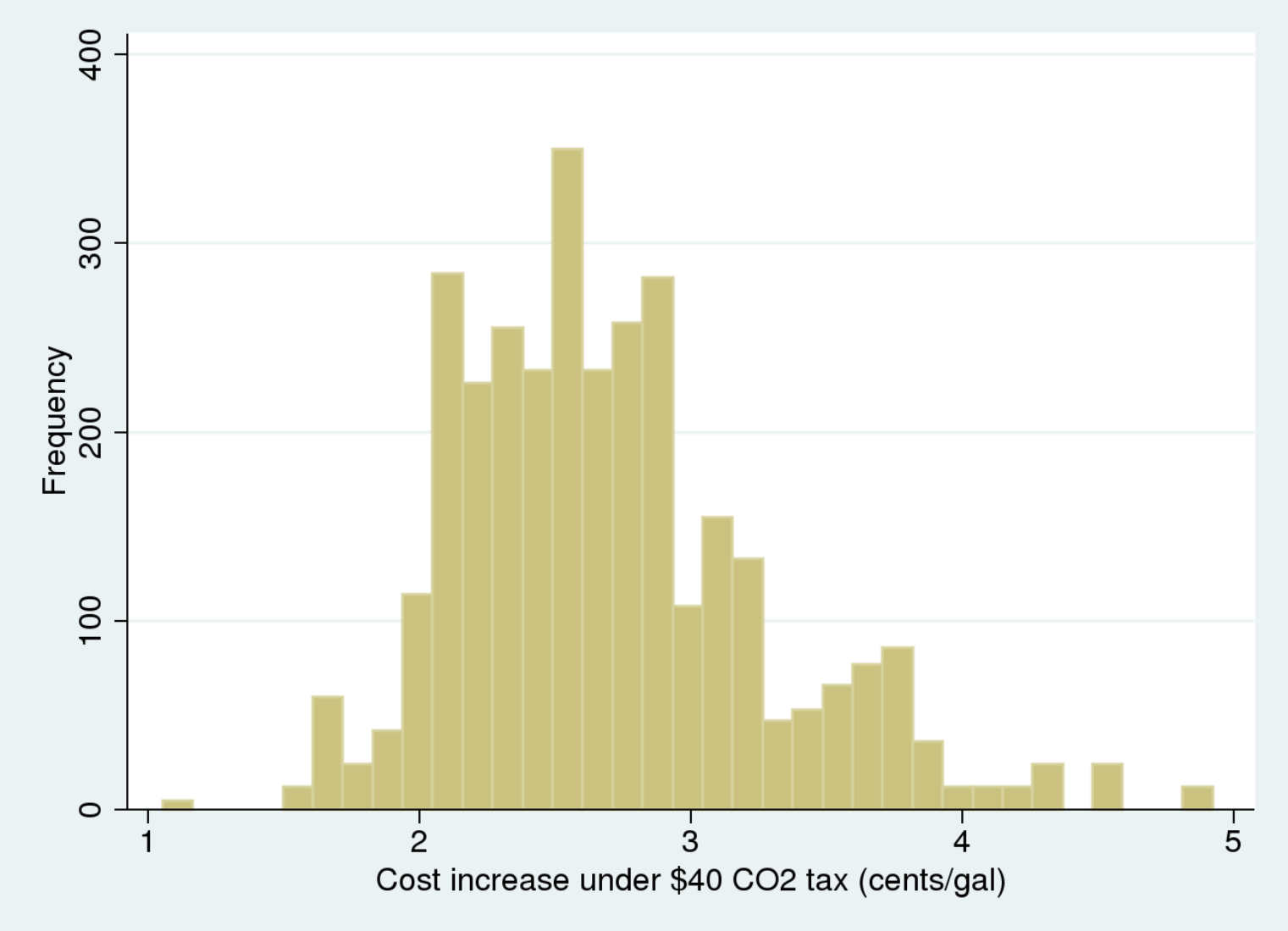
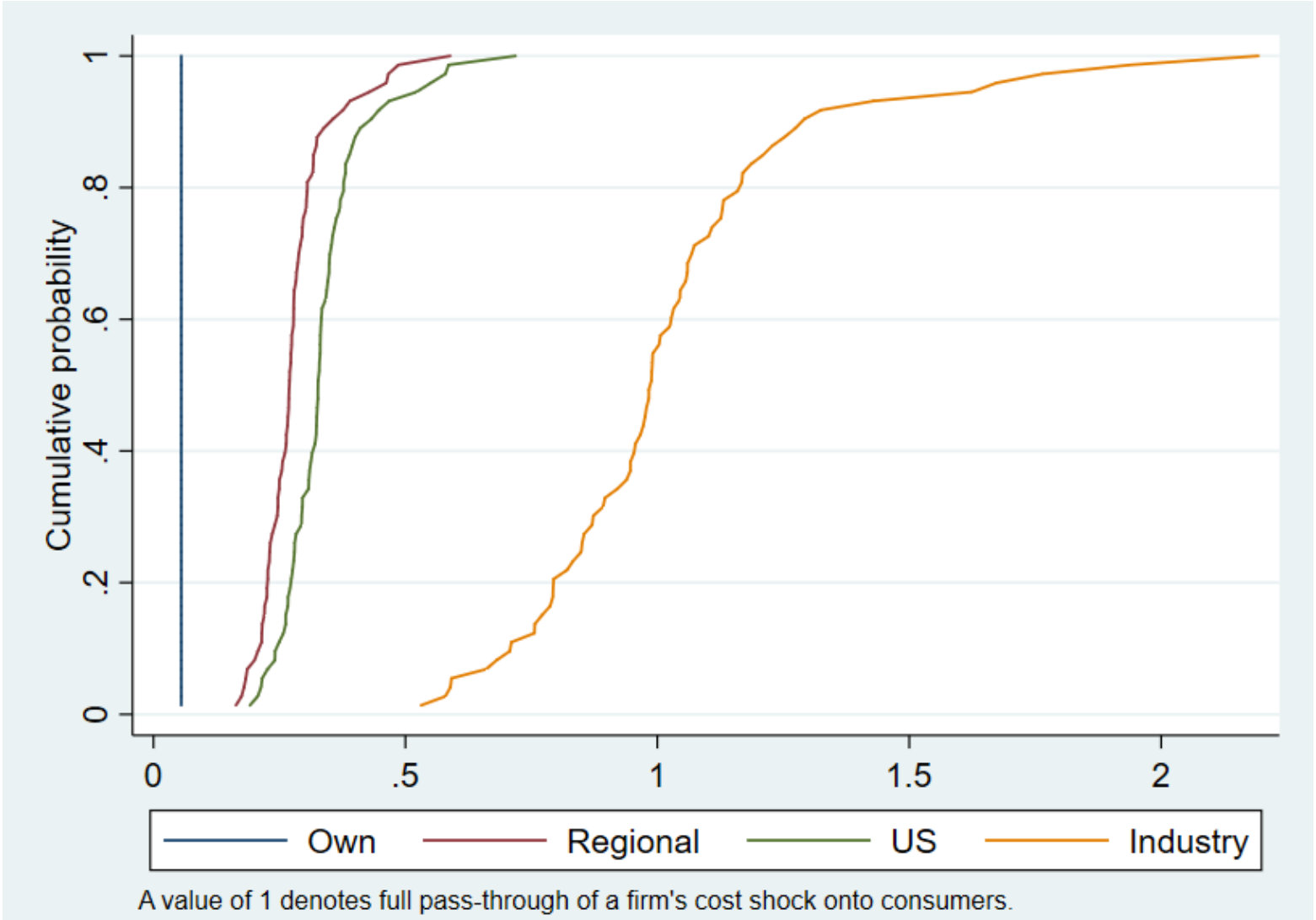
Idea: Even though we don't currently tax refinery carbon emissions, we can predict what might happen to prices from our pass-through estimates.

CO2 tax heterogeneity under $40 CO2 tax



Based on annual data (2011-2015) in EPA GHGRP

Pass-through of a C02 Tax by scope



- direct effect alone = firm bears full incidence
- taxing entire industry = consumers bear full incidence

Summary on incidence empirics

- If we know the elasticities (and assume perfect competition), we can predict incidence.
- Often we don't know these though... so many papers try to estimate the extent to which cost or tax changes are passed on to consumers.
- A challenge here is finding exogenous cost or tax changes.
- When making predictions about a new policy, it's important to account for imperfect competition and the scope of the cost shock.