

Estimating Elasticities: Application to the Shale Gas Boom

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Outline

- Elasticities are arguably the most important objects in economics
 - Quickly review some applications
- Then are also tricky to estimate
- Application: Shale gas boom

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Recap on incidence: Example tariffs

AUG 2, 2019

Truth-squading Trump's tariff claims

The president has said again that China, not the U.S. consumer, pays the cost of tariffs. Economists say that's false.

Trade showdown | by Mitchell Hartman

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President Donald Trump speaks during a cabinet meeting in February.
Mandel Ngan/AFP/Getty Images

How much will tariffs be passed on to consumers?

- Draw moderately sloped Supply. Add tariff.
- If D is elastic, then the price increase will be small.
- If S is inelastic, then the price increase will be large.

If we know the elasticities of supply and demand, we can compute the incidence of any tax or tariff.

Consumer share of burden:

$$\frac{\text{Change in Consumer Price}}{\text{Tax}} = \frac{\varepsilon_S}{\varepsilon_S + |\varepsilon_D|}.$$

Examples:

- $\varepsilon_S = 0.5, \varepsilon_D = -1 \Rightarrow 1/3$ of the tax is passed on to consumers.
- $\varepsilon_S = 3.0, \varepsilon_D = -1 \Rightarrow 3/4$ of the tax is passed on to consumers.

The demand elasticity was also important for our carbon tax discussion.

- Assumptions about the SCC deliver some change in the gas price
 - In our example, price increased by 85%.
- How much will that reduce emissions from gasoline?
- Answer depends on elasticity of demand.
 - If $\varepsilon_D = -0.1$, then emissions fall by 8.5%.
 - If $\varepsilon_D = -0.5$, then emissions fall by 42.5%.
 - If $\varepsilon_D = -1.0$, then emissions fall by 85%.

The demand elasticity also determines how firms set prices

- We briefly reviewed DWL from market power.
- More generally, how to set prices is probably the most important decision many firms make.
- Profit maximizing firms choose prices such that **marginal revenue** equals marginal cost.
- Lerner index: $\frac{P-MC}{P} = -\frac{1}{\varepsilon_D}$.

Shale gas boom

Widespread concern about NG in early 2000's

Economists, Energy Suppliers Ponder Natural Gas Crunch

By · **Fox News**

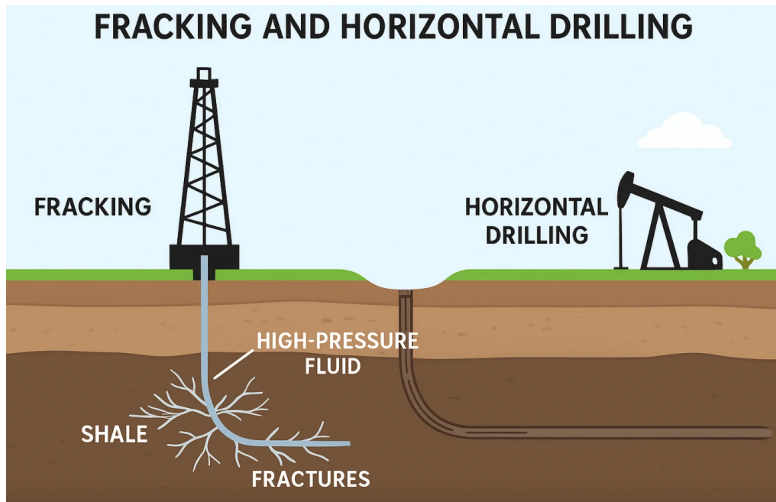
Published June 11, 2003 12:00am EDT Updated January 13, 2015 5:05pm EST

Natural gas prices have risen dramatically — more than doubling in one year — and higher prices are likely to remain throughout the summer, reaching historic records next winter, **Federal Reserve Chairman Alan Greenspan** ([search](#)) said Tuesday.

"We are not apt to return to earlier periods of relative abundance and low prices anytime soon," Greenspan told the House Energy and Commerce Committee.

- U.S. production had been **flat for a decade**.
- Net **importer** of LNG, with plans to import much more.

Then rapid maturation of two technologies made huge shale deposits in the U.S. commercially viable



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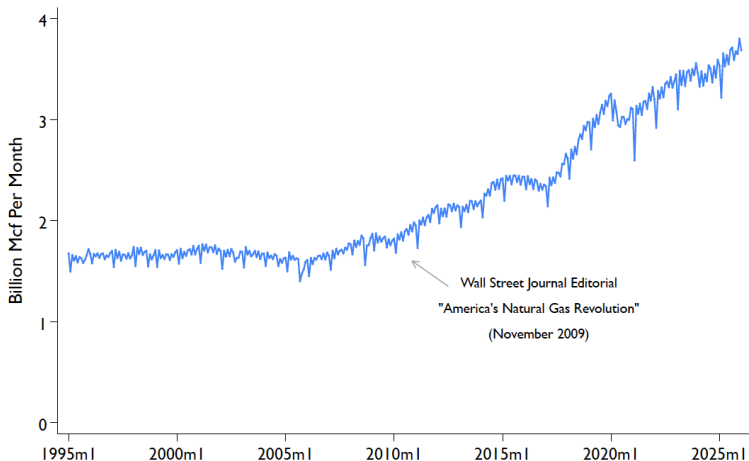
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US natural gas production **doubled** since 2009

Figure 1: U.S. Natural Gas Production

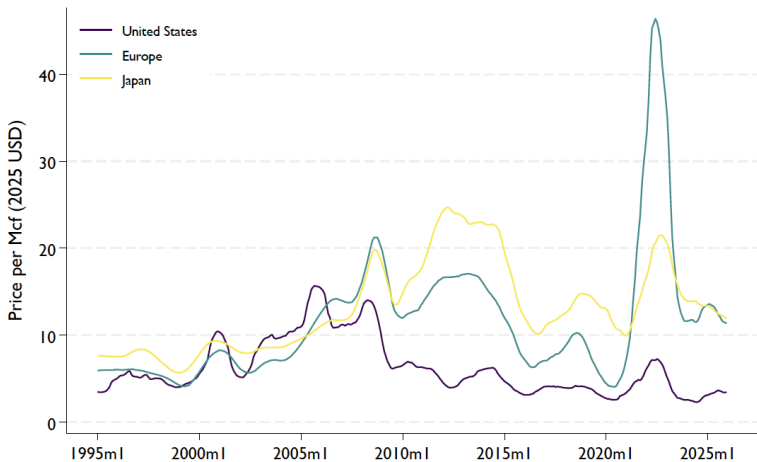


From importer to largest exporter

- The U.S. went from a net gas importer to the **world's largest exporter**.
- But, crucially, U.S. export capacity is limited and export facilities run near **100% utilization**.
- Gas is bulky. Moving it across oceans requires cooling to **-162 °C** to liquefy it for ships
- That constrains US and foreign prices from converging
 - Takes over a decade to bring new export capacity online.

Prices used to move together, then split after shale

Figure 2: Natural Gas Prices in the U.S., Europe and Japan



Summary of price divergence

Table 1: Natural Gas Prices in the U.S., Europe & Japan

	U.S.	Europe	Japan
Pre-Shale (1995-2006)	7.7	7.3	8.5
Post-Shale (2007-2025)	5.3	14.4	16.1

Note: This table reports average natural gas prices per Mcf for three price benchmarks. Monthly data from the three price benchmarks come from the World Bank, Commodity Markets Outlook, Historical Data, "Pink Sheet". Prices have been normalized to reflect 2025 dollars.

A binding export constraint keeps a persistent **wedge** between U.S. and world prices.

Question: how much money did shale gas save U.S. consumers?

To answer, we need the price consumers *would* have paid without shale.

Lucas Davis (2026) makes a simple assumption: without shale, the U.S. would have imported LNG and paid the **world price** (Europe or Japan). The observed foreign price is the counterfactual U.S. price.

A simple approach to measuring consumer benefit

$$\text{Savings}_t = \underbrace{(P_t^{\text{world}} - P_t^{\text{US}})}_{\text{price gap, } \Delta P_t} \times \underbrace{Q_t^{\text{US}}}_{\text{U.S. consumption}}$$

Example for 2025:

- Price gap ΔP (vs Europe) = \$9 / Mcf
- U.S. consumption Q = 30 billion Mcf
- Savings = \$270 billion

Davis repeats this for every year then adds them up.

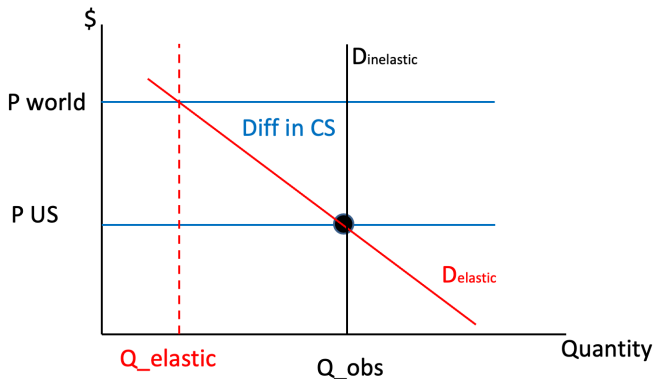
Key assumption: inelastic demand

The formula $\Delta P \times Q$ uses **observed** (post-shale, low-price) consumption Q .

That treats demand as **perfectly inelastic**: consumers would buy the same quantity even at the much higher world price.

Graphically, the benefit is a **rectangle**: height ΔP , width Q . This is an upper bound.

If demand is elastic, then consumers benefited
much less from the price drop



So to estimate how much consumers benefited, we need to
know the price elasticity of demand

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Suppose you wanted to estimate a **demand elasticity** for natural gas

Natural gas uses:

- Residential/ Commercial: heating, cooking, water heating
- Industrial: heating, feedstock for chemicals, electricity generating

We want to know: if the price of natural gas rises, how much will demand for all these uses fall?

How would you do it?

- What data would you need?
- What regression would you run?

Regressing quantity on price

Data:

- Need a data set with prices in each period.
- Need to observe the quantity consumed in each period.
- Probably want to control for other factors that affect demand

$$q_t = \alpha p_t + \beta' X_t + \epsilon_t$$

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What's the key assumption we need in order to estimate α with OLS?

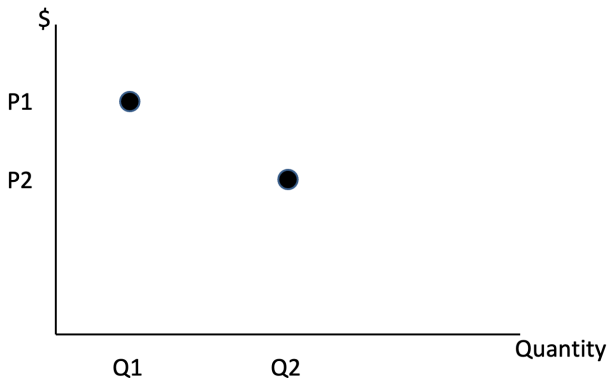
The simultaneity problem

Suppose we regress quantity on price to estimate demand:

$$q_t = \alpha p_t + \beta' X_t + \epsilon_t$$

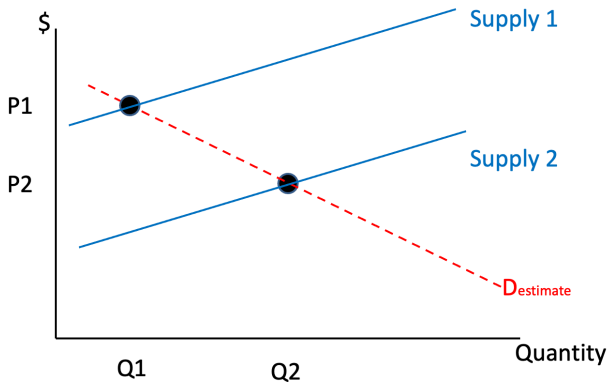
But market prices are **equilibrium** outcomes: They are determined by demand **and** supply.

To estimate a demand curve, we can look at how quantity has responded to price changes in the past



A typical dataset will look like this.
(Often useful to plot prices and quantities in logs)

It is tempting to draw a curve through those points
and call it demand

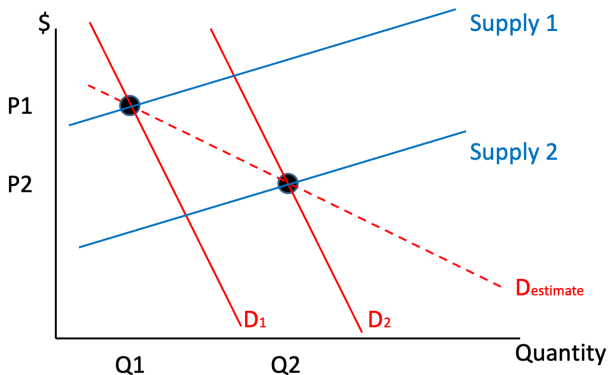


This assumes that only supply changed between periods 1 and 2

Shifts in versus along demand and supply curves

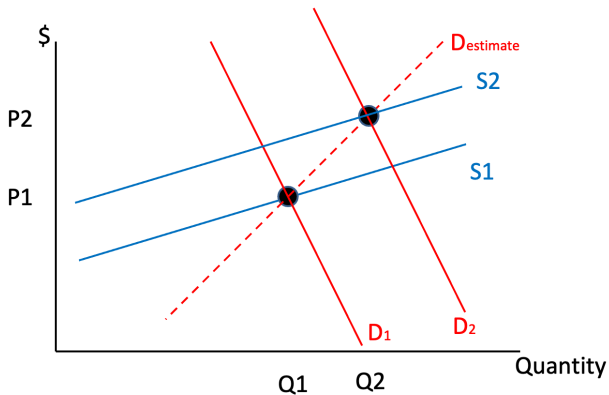
- Take the market for natural gas
- What are some things that cause the intercept of the **supply curve** to shift up / down?
 - These allow use to estimates the slope ($\sim$ elasticity) of demand.
- What are some things that cause the intercept of the **demand curve** to shift up / down?
 - These allow use to estimates the slope ($\sim$ elasticity) of demand.
- **Challenge:** Both curves can move over time

It is possible that supply *and* demand changed between periods 1 and 2



If we drew a line through these two dots and called it “demand” we would have significantly overstated elasticity (in this example)

If supply and demand shocks are positively correlated, you could even estimate *upward sloping* demand



Example: In 2024 Biden impose flaring regulations (increased costs) and AI boom began (increased demand)

What's the solution?

Typically we look for some reason why price moved around that we **know** was due only to supply

Can estimate this using **instrumental variables**:

- 1 Predict price using **just factors that shift supply** not demand (these are the instruments).
- 2 Regress quantity on **predicted price**.

(Note: this is a two-stage least squares regression that R or Stata will do for you.)

Kellogg and Hausman (2015) estimate natural gas demand elasticities using instrumental variables.

- Data: State-month level data on natural gas consumption and prices, 1997-2013.
- Instrument for price: lagged weather in **other states**.

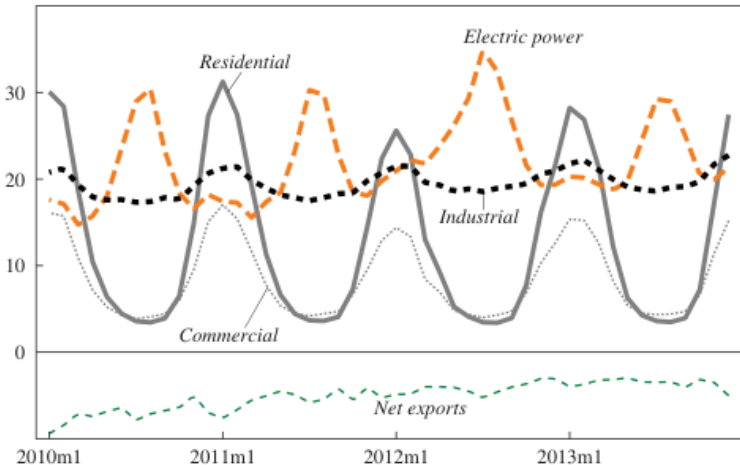
Idea:

- Gas is produced continually and then stored to meet demand
- Cold weather in other regions in **previous months** leads to gas being **taken out of storage** and shipped to those regions
- Which reduces the supply available in the current month, and **raises the price** in the current month.
- **Assumption:** After controlling for current local weather and seasonality, **lagged weather elsewhere** should not directly change a state's current gas consumption, only the prices consumers face.

Why weather is a good instrument

Figure 3. U.S. Natural Gas Consumption by Sector of End Use, 2010–14^a

Bcf per day



Source: EIA.

a. Natural gas used in vehicles, in drilling operations, and as fuel in natural gas processing plants is not shown, but all these amounts are small.

Their preferred long-run elasticities

Sector	Demand elasticity
Residential	-0.20
Commercial	-0.23
Industrial	-0.57
Electric power	-0.47
Total demand, roughly	-0.4

OLS estimates are typically half as large.

Davis presents estimates by elasticity

- All figures are relative to the European price.
- “E” in the top row is the assumed demand elasticity.

Savings	$E = 0$	$E = -0.25$	$E = -0.5$
Total (trillions)	\$4.5	\$3.7	\$3.1
Average annual (billions)	\$237	\$196	\$164
Average annual per capita	\$716	\$590	\$494

Assuming demand is perfectly inelastic ($E=0$) overestimates the consumer benefit by **~30%**.

Export Ban

Current policy question: Should the US export more natural gas?



JOSEPH R. BIDEN, JR.

46th President of the United States: 2021—2025

FACT SHEET: Biden-Harris Administration Announces Temporary Pause on Pending Approvals of Liquefied Natural Gas Exports

January 26, 2024

President Biden has been clear that climate change is the existential threat of our time – and we must act with the urgency it demands to protect the future for generations to come. That's why, since Day One, President Biden has led and

U.S. Department of Energy Reverses Biden LNG Pause, Restores Trump Energy Dominance Agenda

The U.S. Department of Energy, effective today, is ending the Liquefied Natural Gas pause, and returning to regular order.

[Energy.gov](https://www.energy.gov)

January 20, 2025

Should the US export more natural gas?

- What would the effect be on U.S. consumers?
- What about the climate?

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Summary of key points

- The elasticity of demand is a key determinant of many energy and environmental policy outcomes: emissions reductions from a Pigouvian tax, incidence of a any tax or regulation, benefits / costs from tech change/ regulations.
- It's also tricky to estimate because price and quantity are determined **simultaneously** in equilibrium.
 - Know how to illustrate the simultaneity problem graphically.
- Solutions is to find some reason why price moved around that we **know** was due only to supply (demand) when estimating demand (supply) elasticities.
- Ignoring demand response leads to a $\sim 30\%$ overestimate of the consumer benefits from the shale gas boom.