Energy Markets and Economic Efficiency

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Module Overview

Three lectures

1. Review how markets work, and how they can fail to achieve efficiency.
2. Discuss environmental taxes and the social cost of carbon.
3. Discuss the implications the fact that some energy sources (like oil and gas) are finite

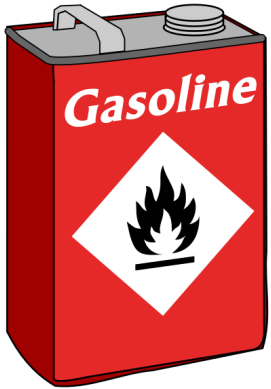
Examples: Oil and gas markets

How markets work

Let's consider the case of gasoline

- The US consumed 136 billion gallons of gasoline in 2025 (EIA).
- Why did we consume that much?
- Was this **economically** efficient?

Deriving the demand for gasoline



- Why do people by gasoline?

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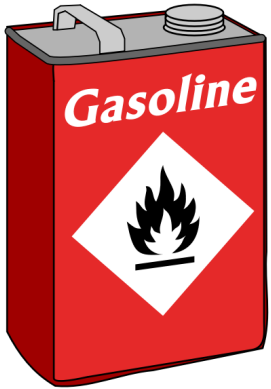

- Why do people by gasoline?
- Can't use it directly. We are about **tranportation services**

Let's start by building up an individual's demand curve

- Start with the first mile you want to travel if you could only take one trip.
- At what price are you indifferent between driving one mile and not?
  - This is the y-intercept
- What about the next mile? Etc.
  - Keep going until you have zero willingness to pay for more miles
  - This is the x-incercept
- For what individuals is this curve steeper / flatter?

From miles to gallons

- Can't use gasoline directly. Need to combine it with a vehicle (capital)
- Let's say your car got 50 miles per gallon.
- Divide x-axis by 50. This is now a **demand curve** for gasoline.
- More (less) efficient cars will cause someone with the same travel demands to require less (more) gasoline

We aggregate *horizontally* across all individuals to get an aggregate supply curve

- Start at the highest williness to pay for the first mile across all people (this is the y-intercept)
- At every price below that, figure out how many people demand a gallon at that price.
- Keep going to zero.
- Key point: This is now a schedule of aggregate (private) **marginal benefits** of gasoline
  - The integral of this curve is the **total benefits** of gasoline consumption.

What are the (private) costs of supplying gasoline?

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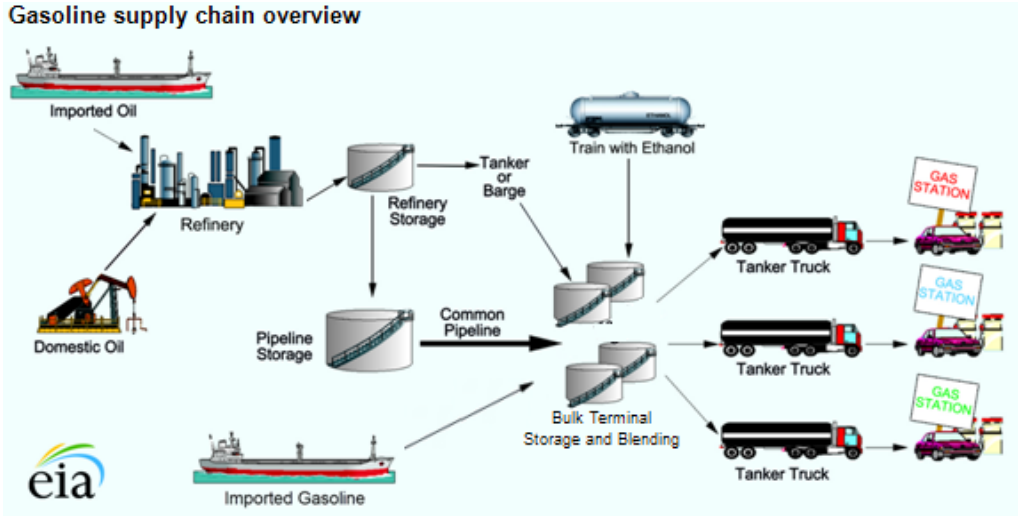
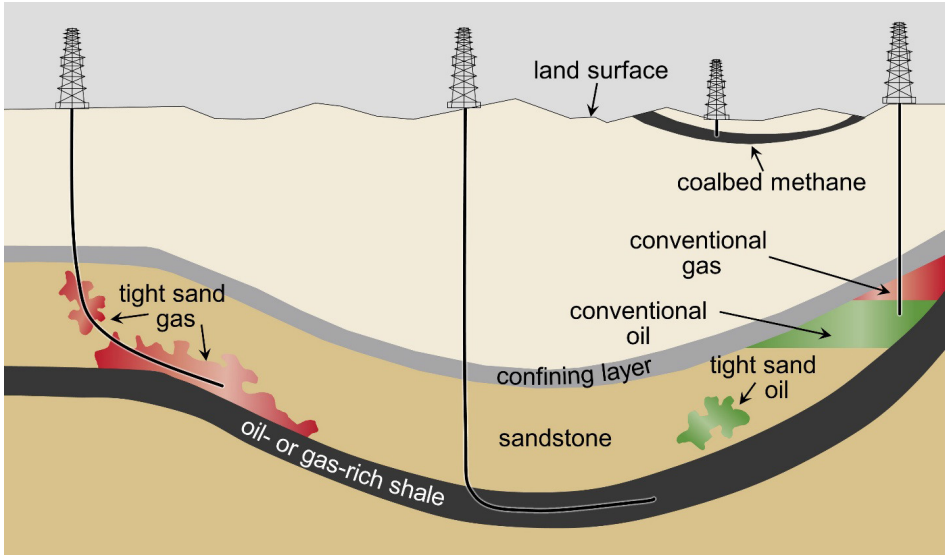
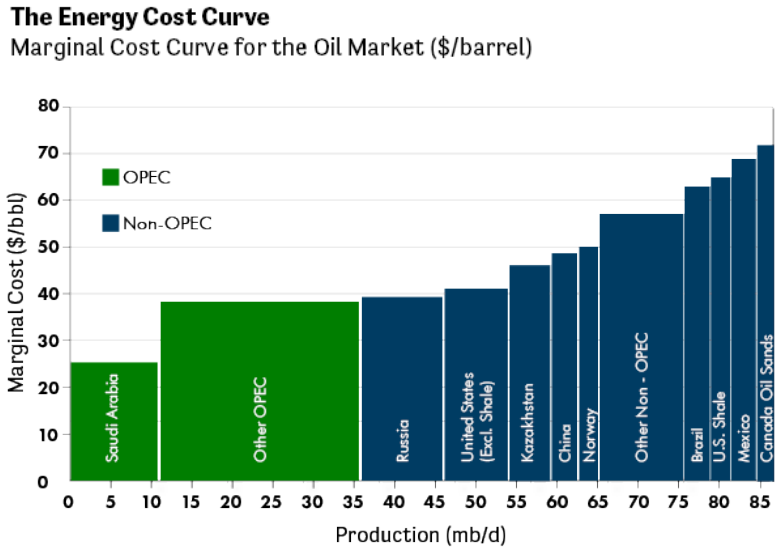


Costs vary depend on how oil is produced



The global oil **supply curve**

- Take the availability of each resource, and line them up in ascending order of **marginal cost**.
- This is the supply curve for oil.
- For any level of production, the **total cost** is the integral of this curve.

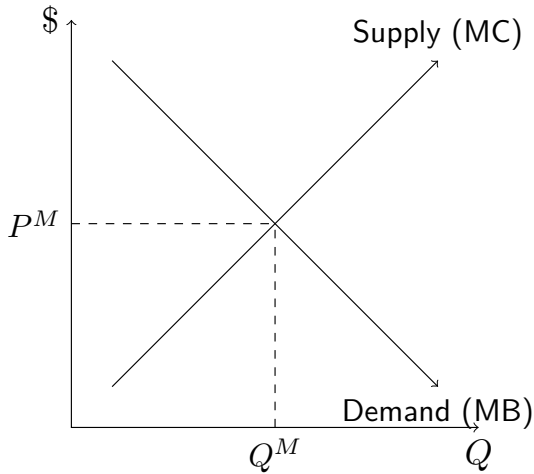


How much gasoline will actually be bought and sold?

Sketch of market equilibrium

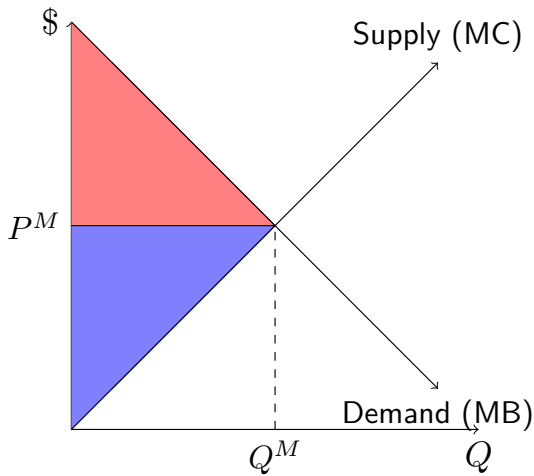
- suppliers come to a market, and reveal the minimum price they'd need to be paid
- demanders come and observe prices. they purchase if the benefit they get exceeds the price they have to pay.
- prices adjust to reflect areas/ markets where goods / services are in excess / insufficient supply.
- able to solve incredibly complex problems, allocating resources where they are valued highest, at the lowest possible cost

How free markets set the level of gasoline consumption



- consumers look at the price, and buy if MB $>$ P
- producers look at the price and sell if MC $<$ P
- P adjusts until everyone who wants oil has it
- Core concept is **free exchange**
  - if two parties agree on a transaction, it *must* make them *both* better off.
  - will continue until no more beneficial trades can be made.

From marginal decisions to total net benefits



- Total expenditure $P^M \times Q^M$
- **Consumer surplus** is defined as the total benefits minus the total expenditure
  - Note: This has to be what consumers actually pay.
- **Producer surplus** is the total expenditure less the total cost.
- Net Benefits = Total Benefits - Total costs

Market failures

Will real-world markets be economically efficient?

Efficiency requires **social** marginal benefits equal to **social** marginal cost

The market outcome will only be efficient when the following conditions are met:

1. Firms and consumers have **perfect information** about the quality of the good being traded
2. The market is **competitive**, meaning that firms and consumers take price as given
3. The market is **complete**, meaning that ALL of the relevant costs and benefits are borne by the producers and consumers involved deciding on each transaction.

Often consumers are not perfectly informed

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Has anyone ever heard of the "lemons'' problem?

An important source of mistakes is which car they buy

Hyundai and Kia fined $100m for misleading customers on fuel economy

Car-makers must also forfeit $200m worth of carbon credits after understating lifetime CO2 emissions on some of its models by about 4.75m metric tons

New Study Shows How Shockingly Expensive It's Become To Drive A Large SUV This Year

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Oil markets are also imperfectly competitive

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Saudi Arabia Won't Change Oil Production Policy

Oil Minister Ali al-Naimi says Gulf state's move to raise local oil prices will increase efficiency

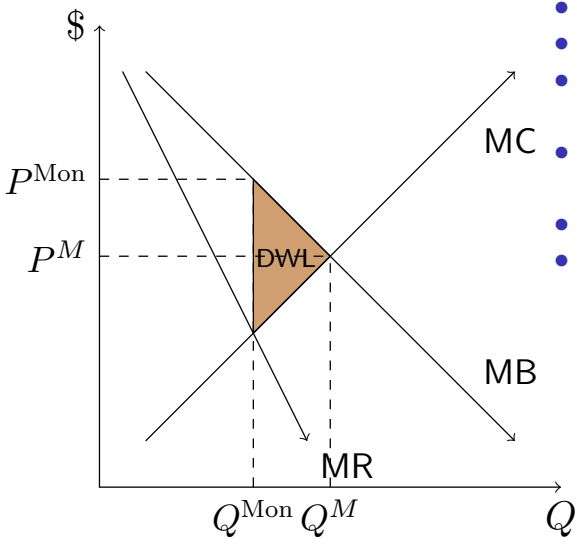
Saudi Arabian Oil Minister Ali al-Naimi, center, arrives at his hotel ahead of a meeting of OPEC oil ministers in Vienna, Austria, earlier this month.The minister said Wednesday the kingdom won't change its production policy despite falling oil prices. *PHOTO: REUTERS*

By **AHMED AL OMRAN** and **SUMMER SAID** **6 COMMENTS**

Updated Dec. 30, 2015 8:42 a.m. ET

RIYADH—Saudi Arabia won't change its current oil-production policy, the

Review of DWL from market power



- Profit: $\pi = P \cdot Q - C(Q)$
- $\frac{\partial \pi}{\partial Q} = P + \frac{\partial P}{\partial Q} \cdot Q - MC = 0$
- Monopolist recognizes: To sell more Q, it has to reduce price.
- This brings new sales, but costs money on existing sales.
- Result: P too high, Q too low.
- DWL is loss from missing net-beneficial sales.

Oil also generates many externalities

An **externality** exists when the consumption or production choices of one person or firm enter the utility or production function of another entity without that entity's permission or compensation.

- This violates the core idea behind the social value of markets: **free exchange**.

What are some important externalities for oil?

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An **externality** exists when the consumption or production choices of one person or firm enter the utility or production function of another entity without that entity's permission or compensation.

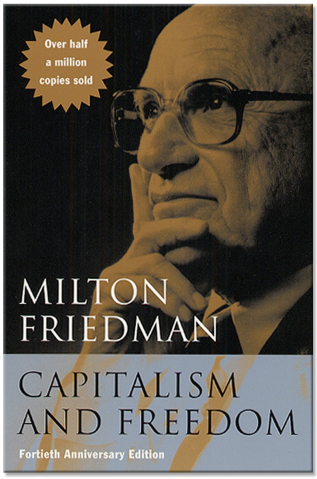
- This violates the core idea behind the social value of markets: **free exchange**.

What are some important externalities for oil?

- Local air pollution
- Oil spills and other accidents
- Climate change
- National security

None of these are paid for by oil producers or consumers.

When externalities are present, **all** economists agree markets will not maximize social welfare



- Common misconception: Economists always advocate free markets
  - In fact, the environment is the canonical example of when economists believe government intervention is necessary to maximize welfare.
- For this reason, environmental protection was historically non-partisan
  - Teddy Roosevelt created park system
  - Nixon created EPA
  - George H. W. Bush ran on and passed first large-scale cap and trade program (Acid Rain)

Some empirical estimates of external costs for oil

- Climate change: 8.89 kg CO2/gal $\times$ \$250/tCO $\approx$ \$2.2/gal
- Local air pollution: health damages $\rightarrow$ \$0.8–0.9/gal nationally
  - enormous spatial variation: \$0.03–\$8+/gal
- Oil dependence / energy security: macroeconomic disruption risk $\rightarrow$ \$0.09/gal

Together: roughly \$3/gallon of external damages, even before congestion and accident externalities.

None of these are paid by drivers.

- Current price: \$4/ gallon

What is the socially efficient level of oil consumption?

- Assume externalities are a constant $2 per gallon.
- Add this to the private marginal cost curve to get the **social marginal cost** curve.
- The efficient level of consumption is where the social marginal cost curve intersects (social) marginal benefits.
- Label these
  - Q^S = socially efficient quantity
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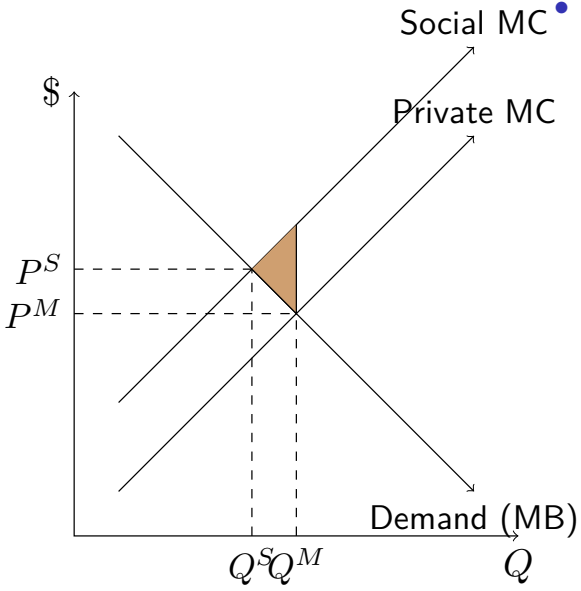
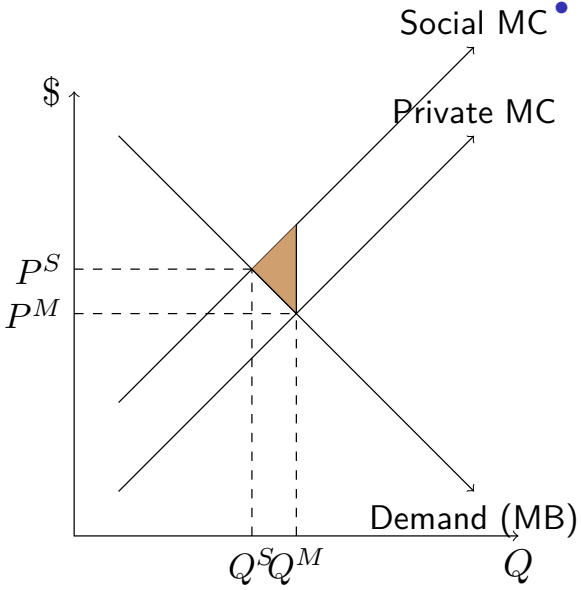
What is the deadweight loss from the competitive market outcome?

Market outcome no longer maximizes welfare



- For every unit of consumption between Q^S and Q^M, marginal *social* costs exceed marginal benefits.

Market outcome no longer maximizes welfare



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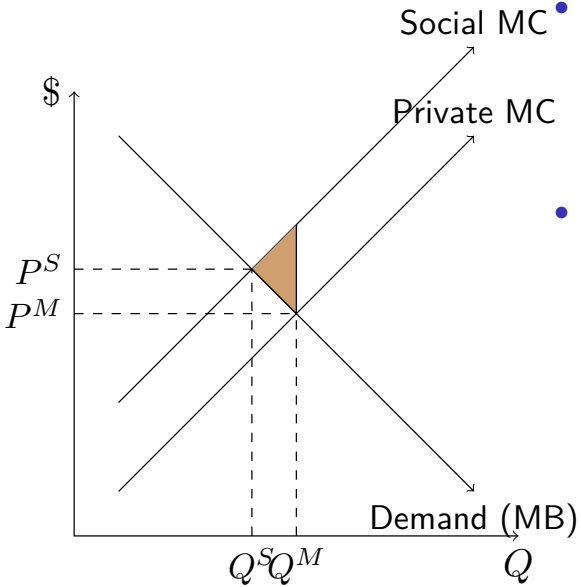

- For every unit of consumption between Q^S and Q^M, marginal *social* costs exceed marginal benefits.
  - This means that consumption is actually *reducing* net social benefits.
- **Deadweight loss** is the integral of the difference beteween MB and MC over that range.

Market power and externalities together...

- The market for gasoline contains both market power and externalities. Do these two market failures work in the same direction, or do they offset each other?
  - ie is OPEC good or bad for the environment?

Two Wrongs Can Sometimes Make a Right: The Environmental Benefits of Market Power in Oil

John Asker, Allan Collard-Wexler, Charlotte De Canniere, Jan De Loecker & Christopher R. Knittel

WORKING PAPER 33115 **DOI** 10.3386/w33115 **ISSUE DATE** November 2024

Market power reduces equilibrium quantities and distorts production, typically causing welfare losses. However, as Buchanan (1969) noted, market power may mitigate overproduction from negative externalities. This paper examines this in the global oil market, where OPEC's market power affects oil production and carbon intensity. We estimate that from 1970 to 2021, OPEC's market power reduced emissions by over 67 GtCO2, equating to $4,073 billion in climate damages and 17.8% of the carbon budget needed for the 1.5○ C Paris Agreement target. This environmental benefit outweighs the welfare loss from distorted production allocation.

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Policy implication: In markets with unpriced externalities, maybe we should also have less stringent anti-trust enforcement.

Lecture summary: Key points I

- Private markets work through free exchange.
  - Buyers determine their **marginal** willingness to pay, and sellers determine their **marginal** willingness to accept.
  - Transactions only occur when both parties are better off (net benefits are positive).
- If all parties are perfectly informed and the market is competitive, then this process will maximize private net benefits (ie the sum of benefits minus costs for all parties involved).
- This free market outcome **will not** maximize **social** net benefits if there are externalities.
- You should be able to calculate the equilibrium price and quantity, surplus, and the deadweight loss in the presence of market failures.