MIT 14.01: Principles of Microeconomics
Sp 2025, Lecture 4: Equilibrium (Intro)

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Plan for Today

1. What happens when we put supply and demand together?
2. Competitive equilibrium
3. Properties of competitive equilibria
4. Non-RCT method for causal inference: regression discontinuity

When Supply Meets Demand

- We have so far introduced two crucial ingredients for the analysis of the exchange of a single good (e.g. bednets):
  - Demand: $Q = D(p)$...how much will consumers buy if price is p?
  - Supply: $Q = S(p)$...how much will firms sell if price is p?

- These are two (interdependent) "if statements"

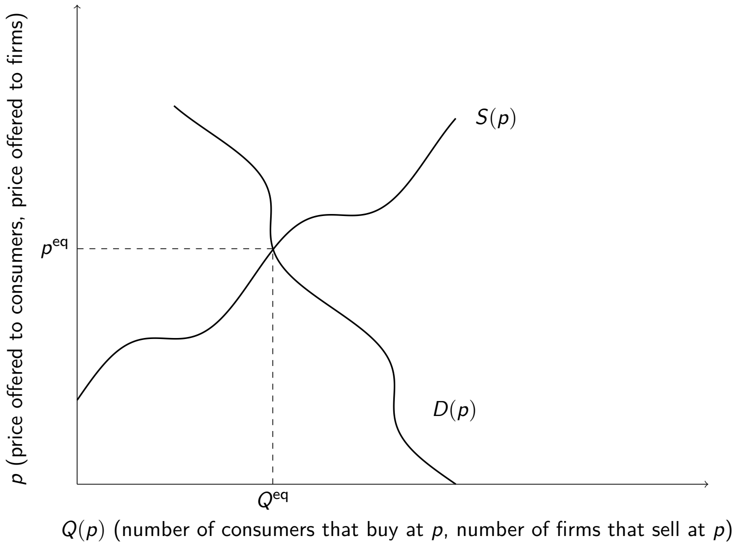
- But what will actually happen?
  - What price will the consumers pay and the firms receive?
  - What quantity will the firms sell to the consumers?

- Now introduce first notion of "equilibrium", a core concept throughout economics
  - To some, the very essence of econ is "mutually-consistent optimization"...
  - Demanders and suppliers each do what's best for them (i.e. they optimize) but their actions need to be consistent with one another (i.e. they need to be in "equilibrium")

Main Equilibrium Concept: Competitive Equilibrium

- **"Competitive":**
  - Agents on both sides take the price as given (i.e. they know, correctly, that they are so small that their actions have only negligible effects on the price)
  - ... as we have in fact already assumed in deriving $D(p)$ and $S(p)$
  - Probably a reasonable assumption when N_C and N_F are large
- **"Equilibrium":**
  - When all agents (all firms, all consumers) face the same price, p^{eq} and this price p^{eq} is the one that makes "markets clear": quantity demanded equals quantity supplied
  - i.e. p^{eq} such that: $D(p^{eq}) = S(p^{eq})$
  - And we'll refer to the equilibrium quantity as $Q^{eq} = D(p^{eq}) = S(p^{eq})$
- Aside #1: We will often call this a *partial equilibrium* since it is only the equilibrium in the market for this one good. Later lectures will introduce multiple goods and hence *general equilibrium*.
- Aside #2: Technically, the above describes a CE without taxes. We'll introduce taxes in Lecture #5.

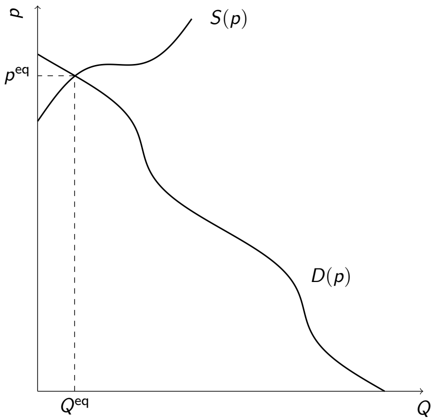
Competitive Equilibrium



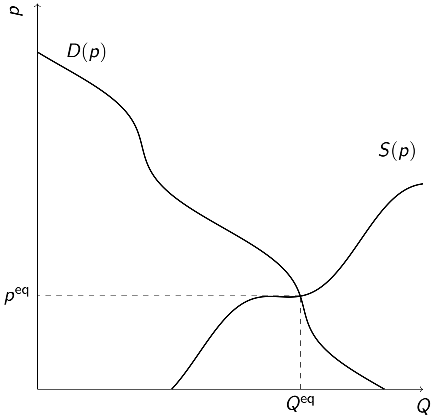
Competitive Equilibrium: Stability

- Why might we think that equilibrium would occur?
  - $D(p)$ only describes what consumers would do *if* price were p, and similarly for $S(p)$
- One answer comes from a notion of *stability*:
  - If $p > p^{\text{eq}}$ then would have *excess supply*: $S(p) > D(p)$
  - And then some suppliers wouldn't be able to sell their goods
  - So they might find demanders and say "wanna make a deal?"
  - And that might lower the market price once other demanders find out
  - (And analogously if $p < p^{\text{eq}}$ we say there is *excess demand*, and a similar argument applies.)

Comparative Statics: Prices Reflect *Marginal* (not Average) WTP

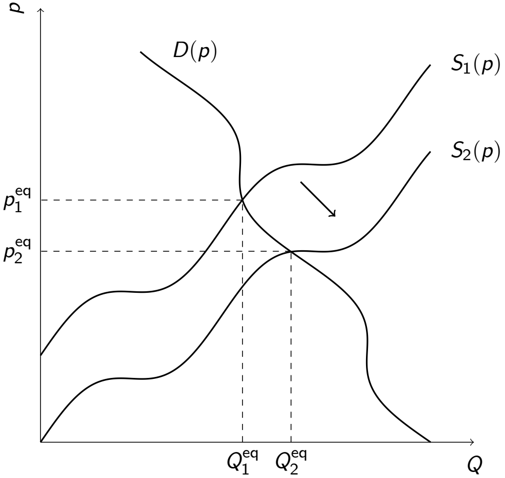


Price of diamonds (and LeBron James) is high because supply is scarce



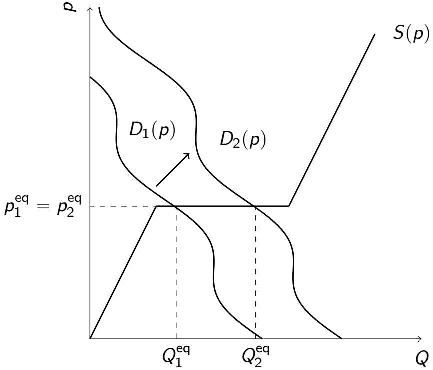
Price of water (and gym teachers) is low because supply is plentiful

Incidence of a Shock

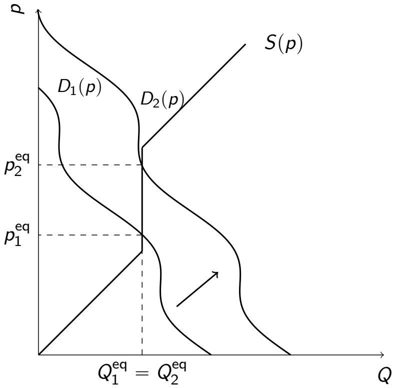


- Suppose the supply function moves outwards (from $S_1(\cdot)$ to $S_2(\cdot)$) by 10%—because all firms saw their costs fall by 10%
- Usual case: prices go down, but by less than 10%
- The "incidence" of the supply shift falls on:
  - Consumers, who get lower prices
  - And firms, whose seemingly fantastic 10% cost savings is partially offset by the price drop. (Firms make the good more cheaply, but also sell more of it. So now selling to more low- valuation consumers than before. Hence cost savings not so good after all.)

Incidence of a Shock (e.g. a Shift in Demand) Can Fall Completely on Either Side of the Market

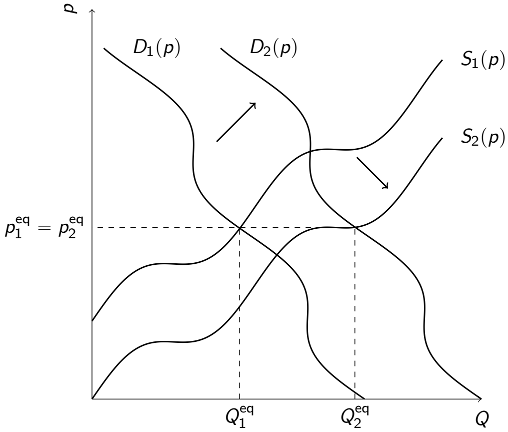


Shift in $D(\cdot)$, but occurs in region where $S(\cdot)$ is perfectly elastic – so incidence borne entirely by producers (price doesn't go up)



Shift in $D(\cdot)$, but occurs in region where $S(\cdot)$ is perfectly inelastic – incidence borne entirely by consumers (price goes up by full vertical amount of demand shift)

Sometimes Both Curves Get Shocked



- E.g. public health policy has both an information campaign (raises consumer valuations for bednets) and a local training component (lowering cost of making bednets)
- In general, quantities will always grow. But price may rise, fall or stay the same (as shown here, despite neither curve being perfectly elastic).

Example: Love Canal (Niagara Falls, NY)

- From about 1920-1950, William T. Love's canal was used as open dumping ground for local chemical and plastics companies
- Around 1950 it was filled in with soil, and an elementary school was even built on top
- By 1978 the toxic waste was seeping into local groundwater
- Inspired 1980 federal "Superfund" act, which cleaned up this site (and thousands of others to this day) at cost of around $40 million per site

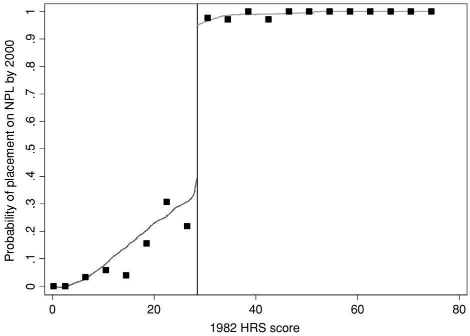
How Much Was Superfund Cleanup Worth?

- Ideally we'd collect data on outcomes "Y" that we care about (e.g. child health) and convince the US government to run an RCT
  - Draw up a list of toxic waste dump sites that are Superfund-eligible
  - Ask government to clean up a randomly chosen half ("treatment") of the sites, and leave the other half untouched ("control")
  - And (since we expect some impacts to take a while) leave the control sites uncleaned for a long time

- Good luck with that!

- What we need is a "natural experiment" that might plausibly mimic this RCT...

Regression Discontinuity: A Non-RCT Method for Causal Inference



- Potential Superfund sites i were proposed to the EPA, which (in 1982) assigned them a priority score s_i from 0 to 80

- Govt. then applied a rule that those sites above the cutoff score value $\bar{s}$ (of 28.5) get cleaned up ("put on NPL"). See figure.

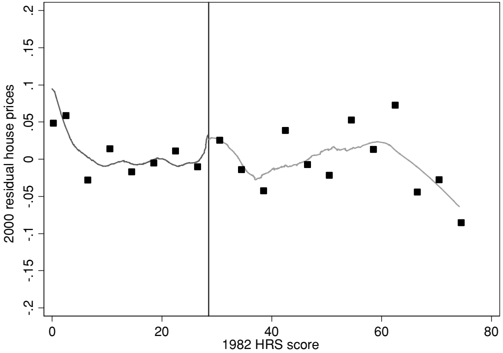
- Seems plausible that for small ε:

$$\mathbb{E}[Y_i(T)|s_i = \bar{s} + \varepsilon] = \mathbb{E}[Y_i(T)|s_i = \bar{s} - \varepsilon]$$

and $\mathbb{E}[Y_i(C)|s_i = \bar{s} + \varepsilon] = \mathbb{E}[Y_i(C)|s_i = \bar{s} - \varepsilon]$

- So (even though s_i is definitely not randomly assigned) comparing sites with s_i just above/below $\bar{s}$ could mimic an RCT

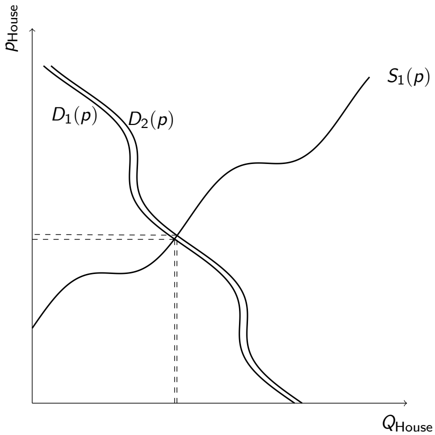
Impact of Superfund Cleanups on Local House Prices



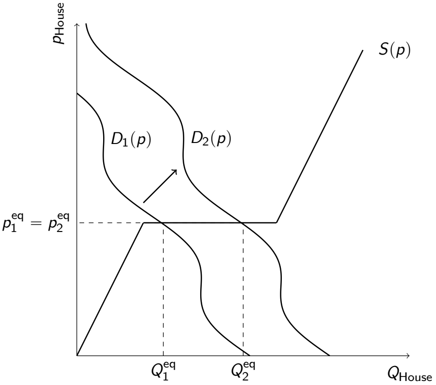
From Greenstone and Gallagher (*Q. J. Econ.*, 2008)

- Suppose that an outcome of interest "Y" is "residual" (i.e. quality-adjusted) 2000 house prices nearby every potential Superfund site
- The dots in this plot are estimates of $\mathbb{E}[Y_i|s_i = s]$ at various score values s. Hence the vertical difference between dots at s that are "just" on either side of $\bar{s}$ correspond to $\mathbb{E}[Y_i|s_i = \bar{s} + \varepsilon] - \mathbb{E}[Y_i|s_i = \bar{s} - \varepsilon]$.
- Hence this is a valid estimate of $\mathbb{E}[Y_i(T) - Y_i(C)] = ATE$ for the case of:
  - T (i.e. treatment) = cleanup happens
  - C (i.e. control) = cleanup doesn't happen
- Suggests very little impact on house prices (and paper shows same is true for rental rates)

Two Possible Interpretations



There was a small shift in $D(\cdot)$—Superfund is not really valued by local residents



There was a big shift in $D(\cdot)$—Superfund is quite valued by local residents) but $S(\cdot)$ is perfectly elastic so no effect on house prices. However, this would imply a large increase in houses built/sold, and authors look at that "Y" too and the effects are small.

Is the CE Allocation a "Good" One?

- What is an *allocation*?
  - The physical quantities that each consumer gets and each firm produces
  - (Allocation is physical: nothing *per se* to do with prices!)
- What do we mean by "a good allocation"?
  - The world of this model has lots of different "agents": N_C consumers and N_F firms
  - Lots of different ways to rank allocations here depending on which agent(s) we consider most important: e.g. we could prefer what's best only for firms, only for consumers, or only for consumer #1...
- This is our first foray into *normative* ("what should be") rather than *positive* ("what is") analysis...

One concept of “good” is Pareto Efficiency (PE)

- *Pareto efficiency* (or “Pareto optimality”): An allocation is Pareto efficient whenever it is impossible to make a change that would benefit one agent and leave all other agents unharmed by that change

- More simply: a PE allocation optimizes over all possible “win-win” and “win-no harm” rearrangements until there are none left (i.e. any further rearrangements have to be either “win-lose” or “lose-lose”)

- Is PE a good definition of “good”?
  - Many consider PE to be a pretty uncontroversial notion of “good”. But there is nothing wrong with saying “I prefer allocation X even though it is not PE” (e.g. because it really benefits my favorite person, perhaps at the cost of Pareto efficiency).
  - In practice, PE may not always be that *useful* a definition of “good” because there will often be lots of PE allocations (so we’d need some other criterion to rank the PE ones)

First Welfare Theorem

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- *First Welfare Theorem*: If the economy does not feature any taxes/regulations (or "market failures", something we will define in future lectures) then the competitive equilibrium is Pareto efficient.
  - In short: "The CE is PE"
- We will now cover the intuition for this theorem in the context of the simple model of supply and demand we have started with, but it turns out to continue to hold under *much* more general conditions

Why is the First Welfare Theorem True?

- Basic logic (in special case of today's simple CE model):
  - At the CE, can think of all the Q^{eq} consumers with $B_i = 1$ and the Q^{eq} firms with $S_i = 1$ as "matched" in a trade. (The exact identity of these matches is irrelevant.)
  - And can think of the $N_C - Q^{eq}$ consumers with $B_i = 0$ and the $N_F - Q^{eq}$ firms with $S_i = 0$ as not matched with anyone.
  - It is feasible to swap a matched consumer with an unmatched consumer, but this would harm both. (The matched one would lose their $CS_i > 0$ and the unmatched one would be forced to have negative CS_i.) The same argument applies to the firms.
  - And within any match, of course the consumer would like a lower p and the firm would like a higher p, so we can't rearrange the price in a Pareto-improving way among them.
  - So the CE is PE.

- More simply: at the CE, all trades that happen are mutually beneficial (and can't be improved upon in a mutually beneficent way), and all the trades that don't happen are ones that the prospective trading partners wouldn't want to happen.

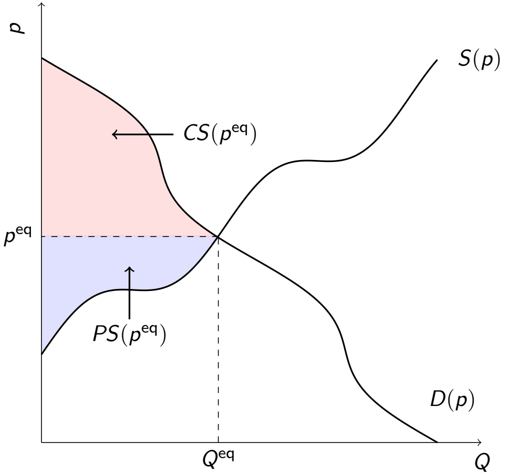
On the First Welfare Theorem

- Sometimes called "the invisible hand theorem"
  - Because relates to ideas in Adam Smith's (1776) quote: "It is not from the benevolence of the butcher, the brewer, or the baker, that we can expect our dinner...he intends only his own gain, and he is in this ... led by an invisible hand to promote an end which was no part of his intention."

- Multiple interpretations of the FWT:
  - To some: why free markets are great
  - To others: market failures are pervasive, so policy must intervene and improve upon free market allocations

- But either way, the theorem implies that it only makes logical sense to criticize free market (i.e no taxes/regulations) allocations if you are arguing along one (or more) of the following lines:
  1. Disputing that agents' behavior is competitive
  2. Have ethical view that prefers a Pareto inefficient allocation to a PE one
  3. Stressing the role of specific market failures (which we'll get to in later lectures)

Total Surplus (and How the CE Maximizes It)



- Define $TS(p) \equiv CS(p) + PS(p)$
- Try to maximize total surplus...
  - Let $p^* \equiv \arg\max_p TS(p)$
  - FOC: $-\frac{dCS(p^*)}{dp} = \frac{dPS(p^*)}{dp}$
  - $\Rightarrow D(p^*) = S(p^*)$
  - $\Rightarrow p^* = p^{eq} \iff Q^* = Q^{eq}$
- Intuition based on "matching":
  - Let cons. i match with firm $f(i)$, so ith match creates $TS_i \equiv v_i - c_{f(i)}$
  - Optimum: do matches with $TS_i \geqslant 0$ (and not $TS_i < 0$). Marginal trade has $v_i = c_{f(i)}$, so must be $p = p^{eq}$

CE Maximizes Total Surplus

- This is a different result than the FWT – saying that CE is good because it optimizes TS amounts to taking a “utilitarian” view on ethics (unlike Pareto efficiency, which does not)
  - *Utilitarian* social objective function: total social utility is equal to the sum of all the agents’ utility levels

- So be careful with this result...
  - Defining $TS = CS + PS$ was laden with value judgements (all consumers to be valued equally, all firms to be valued equally, and consumers valued same as firms)
  - CE maximizes this TS but not some other definition of “total good in this society” that you might think is preferable (doesn’t even maximize $\alpha CS + (1-\alpha)PS$ unless $\alpha = \frac{1}{2}$)
  - In fact, we will see in later lectures that the more generalized (i.e. beyond the quasi-linear utility model we’ve been using so far) econ approach to utility doesn’t even allow for comparisons across people. So you certainly can’t add the utilities across people. Thus it has deeper problems than even the ethical ones of utilitarianism. This is part of the reason that economists prefer Pareto efficiency as an ethical principle.

Concluding Remarks

- **Key concepts from today's lecture:**
  - Competitive equilibrium (CE): p^{eq} at which $S(p^{\text{eq}}) = D(p^{\text{eq}})$
  - Markets with high prices are those with scarce supply and/or limited demand
  - Incidence of a $S(\cdot)$ or $D(\cdot)$ shock: depends on the elasticity of the *other* function
  - Regression discontinuity method for causal inference
  - Pareto efficiency (PE): allocation at which can't make things (weakly) better for all
  - First Welfare Theorem: The CE is PE (if no market failures or taxes/regulations)
  - Total surplus ($= CS + PS$) is optimized at the CE (in the model we've seen so far)

- **Next lecture:**
  - Policy interventions (e.g. taxes, rent control) that alter the CE
  - How do they work? What do they do?