Economics 134 L2

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October 1, 2025

Plan for today

Question from last lecture: balancing the **firm's profits** against the **environmental harm** done to the neighbor.

↪ described "free market" equilibrium outcome

- argued that it did not maximize total surplus

Key question: how should we balance environmental **protection** with **use**?

1. Social choice (which social objective to maximize)
2. Policy solutions to the externality problem
   - Apply cost-benefit analysis
   - Study different policy designs

Social choice

Q. How should we balance environmental **protection** with **use**?

Examples:

1. What level of air pollution to allow?
2. How much land should be conserved to protect endangered species?
3. When should private development occur in mountain ranges?

Each of these questions involve **collective** decisions. They reflect many individuals' preferences, some of whom care deeply about the environment and some of whom don't care at all!

For economists, the answers depend on both

1. individual preferences
2. social choice rules (ways of aggregating preferences)

Santiago, Chile on 22 June 2015

Three examples

1. Air pollution in Santiago
   - Severe air pollution; diesel buses are a big contributor.
     - 18 million trips every day; 30% using public transport
   - Reduction in diesel may raise cost of public transport.
   - This could hurt low-income residents who rely on public transit, but not those who do not use public transit
   - A simple vote seems likely to leave things as they are.
   - A willingness-to-pay (WTP) approach may weight the wealthy more heavily because they own more resources.
   - Not obvious which approach is better, or how to account for distributional issues.

California Gnatcatcher

Three examples

2. California Gnatcatcher

- Small gray bird that lives in Southern California and is an endangered species.
- It likes coastal areas of S. California, but so do humans.
- Protection requires land that could otherwise be used for oceanfront housing.
- Not obvious how to decide. If with a vote, who should vote? The world, the country, the state, just southern California, future generations?

Mineral King Valley, California on 13 August 2021

Three examples

3. Mineral King Valley, California

Walt Disney proposed construction of a ski resort in the 1960s.

- Benefits of the construction
  - Walt Disney Company profits
  - Visitor consumer surplus
- Costs
  - Destroys ancient valley, streams
  - Irreversible consequences
- In part, the example raises a tradeoff between potential gains today vs. losses tomorrow.
- Not obvious how to include future generations in the decision.

Let's keep these examples in mind as we continue.

Individual preferences

Model: N individuals, indexed by $i \in \{1, 2, \ldots, N\}$.

We will focus on a vector of allocations, denoted $q = (q_i)_{i=1}^N$.

For example, q_i might include i's income y_i, and some measure of environmental quality e, so that $q_i = (y_i, e)$.

Each individual i has utility

$$u_i(q_i)$$

over q_i. For example, it could be that $u_i(y_i, e) = y_i + v_i(e)$ for each i.

Various tastes for the environment; e.g.,

- "moral obligation to protect the environment above all else"
- "the environment is valuable only when it is instrumentally useful to humans"
- "moral obligation to preserve the environment for the future"

Need to aggregate these diverse preferences into **social welfare**.

1. Pareto criterion

Our first example of a social choice rule is the Pareto criterion. Named for Vilfredo Pareto (1848–1923).

Definition (Pareto criterion)

For any two allocations q and $\tilde{q}$, we say that q **Pareto dominates** $\tilde{q}$ if

- for all individuals $i \in \{1, 2, \ldots N\}$, $u_i(q) \geq u_i(\tilde{q})$, and
- for at least one individual j, $u_j(q) > u_j(\tilde{q})$.

The **Pareto criterion** is the social decision rule that chooses the allocation q over $\tilde{q}$ if and only if q Pareto dominates $\tilde{q}$.

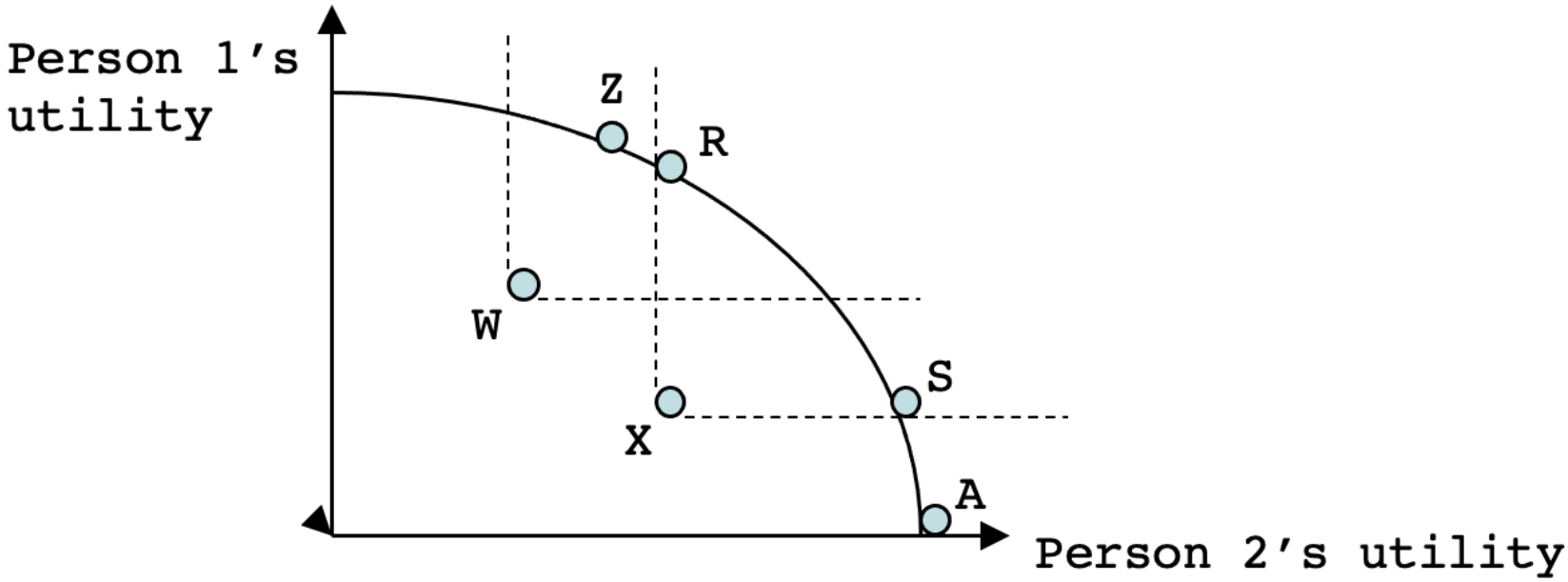
That is, q Pareto dominates $\tilde{q}$ if switching to q from $\tilde{q}$ makes

- no one worse off
- someone better off

This identical to unanimous voting—if all individuals prefer one alternative to another, then so should society!

1. Pareto criterion (cont'd)

Example



- Z Pareto dominates W
- S Pareto dominates X
- But Z and X **cannot be ranked** with the Pareto criterion
- Neither can A and Z (!)

The Pareto criterion risks paralyzing policy choice and maintaining the status quo.

2. Pareto with transfers

A major concern with the Pareto criterion is that it rules out moving from X to Z.

↪ even a very small loss for one person precludes large gains for another

But what if we allow **transfers** between agents?

Let y be a vector of individual incomes and t be a vector of transfer payments that sums to zero (i.e., $\sum_{i=1}^{N} t_i = 0$).

Definition (Potential Pareto improvement)

We say that q admits a **potential Pareto improvement** upon $\tilde{q}$ if there exists transfers t summing to zero such that $(q, y + t)$ Pareto dominates $(\tilde{q}, y)$.

Then, Z admits a potential Pareto improvement over X if 1 can remain better off after compensating 2 for their utility loss (due to the move from X to Z).

- If we consider money on the axes (instead of utility), then R is the outcome that should emerge if Z is a potential Pareto improvement on X.

2. Pareto with transfers

Kaldor-Hicks criterion

We can use this idea of transfers to construct a second social choice rule, named for the British economists Nicholas Kaldor and John Hicks (1939).

Definition (Kaldor-Hicks criterion)

The Kaldor-Hicks criterion is a social decision rule that chooses the allocation q over $\tilde{q}$ if and only if q admits a potential Pareto improvement upon $\tilde{q}$.

Sometimes known as the "compensation principle."

NB. This criterion **does not** require that the transfer or compensation actually occur.

2. Pareto with transfers

Relationship to cost-benefit analysis

Example. Suppose utility for each i depends on income y_i and environmental quality e as in the example before:

$$u_i(y_i, e) = y_i + v_i(e).$$

Take two choices, $q = (y, e)$ and an alternative $\tilde{q} = (\tilde{y}, \tilde{e})$. Then

$$\sum_{i=1}^{N} u_i(q_i) = \sum_{i=1}^{N} [u_i(q_i) + t_i]$$

whenever transfers t satisfy $\sum_{i=1}^{N} t_i = 0$. In particular, asking if

$$\sum_{i=1}^{N} u_i(y_i, e) \geq \sum_{i=1}^{N} u_i(\tilde{y}_i, \tilde{e})$$

is **the same** as asking if q admits a potential Pareto improvement upon $\tilde{q}$.

$\therefore$ In such a case, all we need to do is look at total surplus (**net benefits**).

3. Voting

A third social choice rule: voting with some majority rule.

- The basic problem with the Pareto criterion is that it requires unanimity. Voting does not.
- Concern: voting does not account for the intensity of preferences (no compensation is possible).

Three examples revisited

1. Air pollution in Santiago due to diesel buses:
   - Pareto criterion would cause the status quo to persist.
   - Pareto with transfers (compensation principle) could lead to a change.
   - Majority rule?
     - If public transit users are the majority of voters, policy is unlikely to change even when total willingness to pay (WTP) for the reform is greater than zero

So, outcomes depend crucially on individual preferences and on the social choice mechanism.

Three examples revisited

2. California Gnatcatcher

- Policy option: buy all coastal land and set it aside
- Financing options:
  a) Tax wealthiest 10% of population.
  b) Tax all citizens equally.
- Pareto criterion: Nothing happens with either (a) or (b) because (presumably) fewer than 100% will support it.
- Pareto with transfers: (a) and (b) are identical, since resources go from supporters to opponents.
- Majority rule: Option (a) seems likely to pass, depending on how the other 90% views the tax. Option (b) is more ambiguous; depends on the median voter's relative preferences over income and conservation.

$\hookrightarrow$ Outcomes vary with preferences and social choice mechanism.

Three examples revisited

3. Winter Disneyland in Mineral King

- Pareto criterion: unlikely to pass; at least one person probably cares more about the natural landscape than about skiing
- Pareto with transfers: could pass (though, cannot easily transfer resources across generations—particularly from future to present)
- Majority rule:
  - Only present generation—may pass?
  - Future generations—may fail?

Three examples revisited

1. Air pollution in Santiago
   - 65% reduction in annual $PM_{2.5}$ levels from 1990–2012
   - first three all-electric buses in 2017
   - 455 of 700 buses electric in 2020

2. California Gnatcatcher
   - 70–90% habitat lost since 1940s to land development
   - listed as threatened under the Endangered Species Act

LA Times

https://www.latimes.com/california/story/2025-09-28/camp-pendleton

A view of Camp Pendleton property, including San Onofre State Beach, which is leased by the U.S. Department of the Navy to the State of California, and the permanently closed San Onofre Nuclear Generating Station. (Allen J. Schaben/Los Angeles Times)

Camp Pendleton has won praise for balancing national security needs with environmental preservation.

In 2022, Camp Pendleton was named the U.S. Fish and Wildlife Service's military conservation partner of the year for its efforts to support the recovery of several species, including the tidewater goby, coastal California gnatcatcher, the arroyo toad and southern California steelhead.

Conservation and management of the least Bell's vireo, California least tern, and western snowy plover have resulted in significant increases to on-base populations of these species, according to the agency.

In addition to endangered populations, the base is home to a herd of North American bison, one of

Three examples revisited

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3. Mineral King Valley
   - Sierra Club sued; Supreme Court shenanigans ensued (Sierra Club v. Morton, 405 U.S. 727 (1972))
   - Winter Disneyland was never built
   - Now a national park

Discussion

Economists generally follow Kaldor-Hicks to focus on "efficiency" separately from "equity."

In my view, there are a few reasons for this:

1. If you report the cost-benefit analysis **and** the Pareto-improving transfers, then the (democratically-elected) policymakers can decide for themselves
   - e.g., study efficiency + distributional impacts
2. There exist other mechanisms to redistribute resources. It can be less costly to use those mechanisms directly than to distort environmental policies towards additional, conflicting objectives
3. As a decision rule, even without project-by-project-transfers, applying cost-benefit analysis to many small projects can add up to something that looks more like a true Pareto improvement!

Hotelling's argument for Pareto with transfers

More on that last point:

> *"A further answer to the objection that benefits may be paid for by those who do not receive them [. . .] is that* **no such enterprise stands alone**. *A government willing to undertake such an enterprise [on the basis of the criterion of maximizing total benefits] is, for the same reasons, ready to build other dams in other and widely scattered places, and to construct a great variety of public works. Each of these entails benefits which are diffused widely among all classes. A rough randomness in distribution should be ample to ensure such a distribution of benefits that most persons in every part of the country would be better off by reason of the program as a whole." (Hotelling 1938, pp. 258–259)*

Hotelling's caveat

[I]f some distribution of the burden is possible such that everyone concerned is better off than without the new investment, then there is a prima facie case for making the investment. This leaves aside the question whether such a distribution is practical.

[. . .]

But **the rule must not be applied too harshly**. *Where losses involve serious hardship to individuals, there must be compensation, or at least relief to cover subsistence. When there are many improvements, the law of averages may be trusted to equalize the benefits to some extent,* **but never completely**. *It will always be necessary to provide for those individuals upon whom progress inflicts special hardship; if it were not possible to do this, we should have to reconcile ourselves to greater delays in the progress of industrial efficiency.*
Subject to this qualification of avoiding excessive hardship to individuals, we may adopt the criterion stated. (Hotelling 1938, p. 267)

Externalities, recap

Recall the model's two ingredients. A firm produces some $q \geq 0$ to maximize

$$\pi(q) = p \cdot q - c(q)$$

with increasing and convex costs ($c', c'' > 0$).

A neighbor incurs damages $D(q)$ from q, which is also increasing and convex ($D', D'' > 0$). This is a negative externality.

I. Free market outcome. The firm maximized π by equating price with its marginal cost:

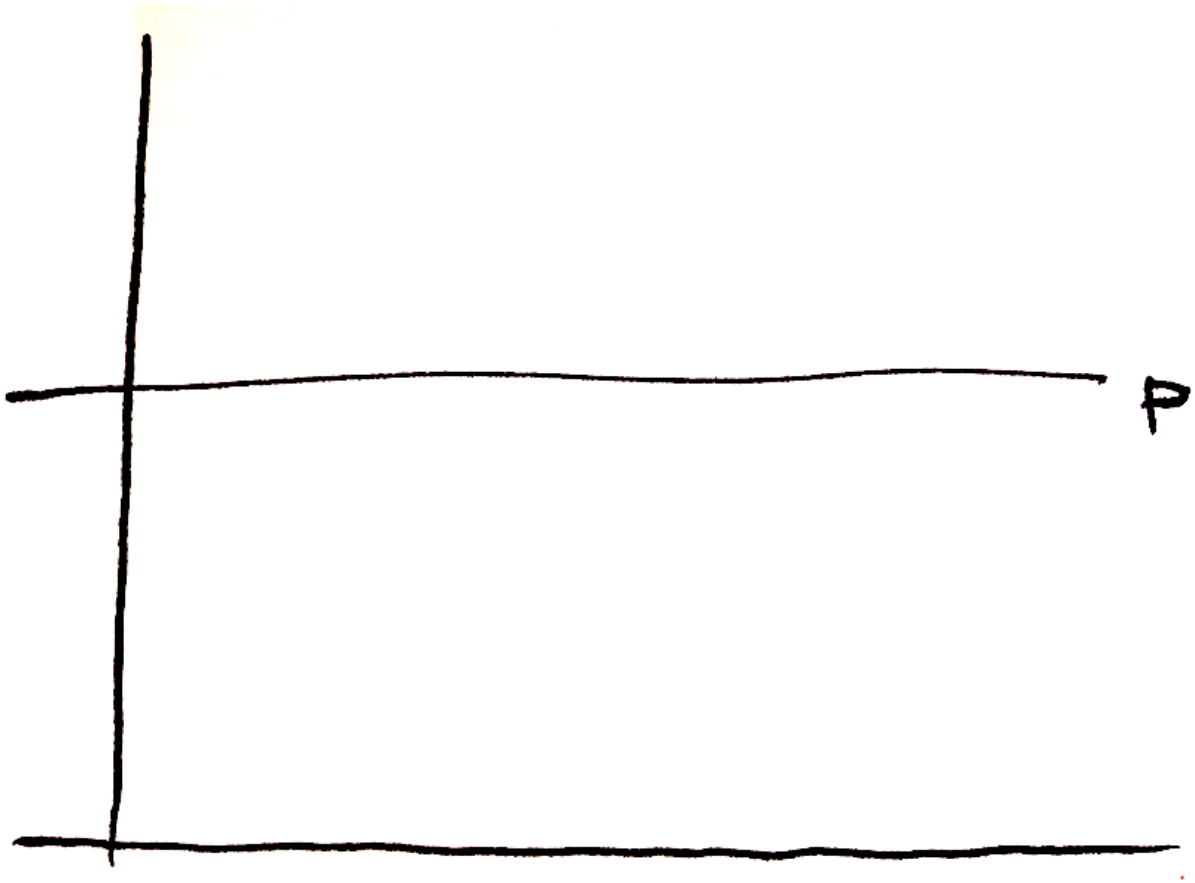
$$\pi'(q^*) = p - c'(q^*) = 0.$$

II. Efficient outcome. Total surplus is maximized at

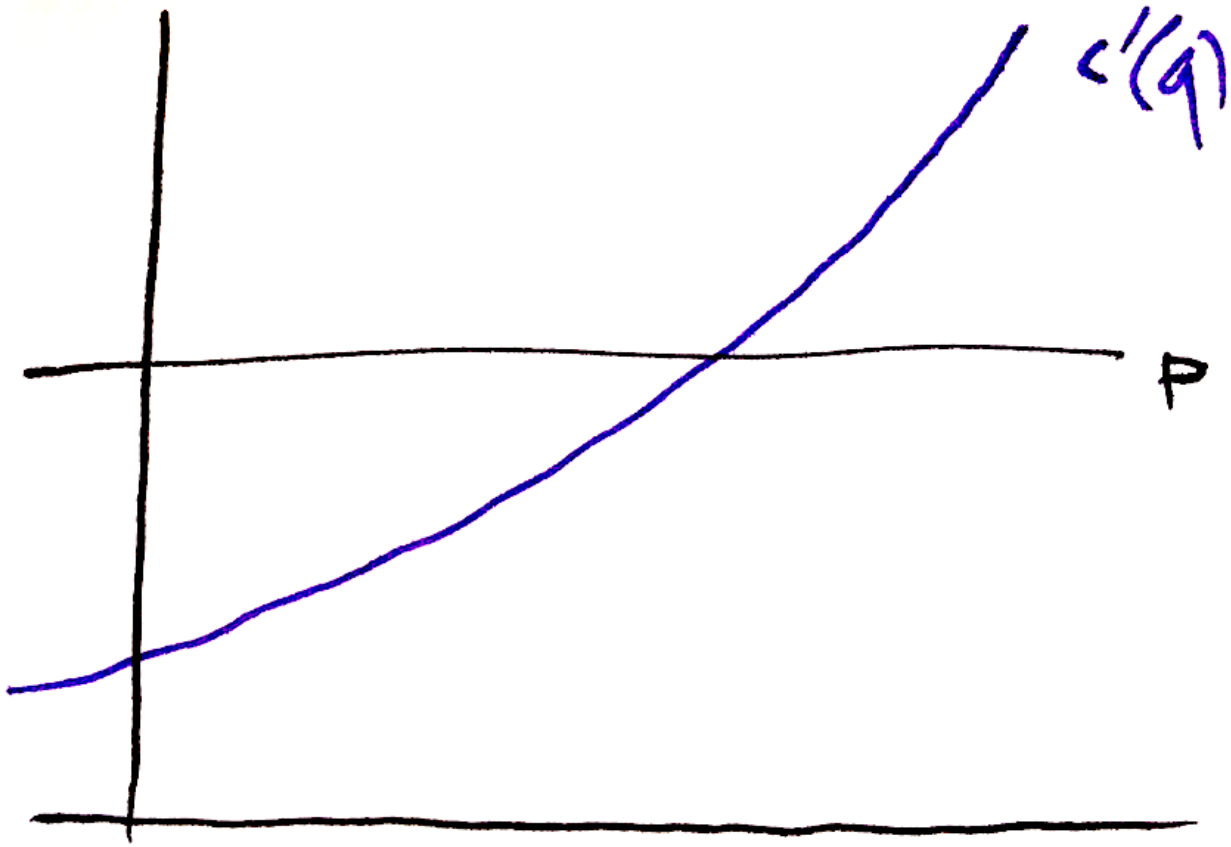
$$q^{\text{FB}} = \arg\max_q W(q),$$

remembering that $W(q) = \pi(q) - D(q)$.

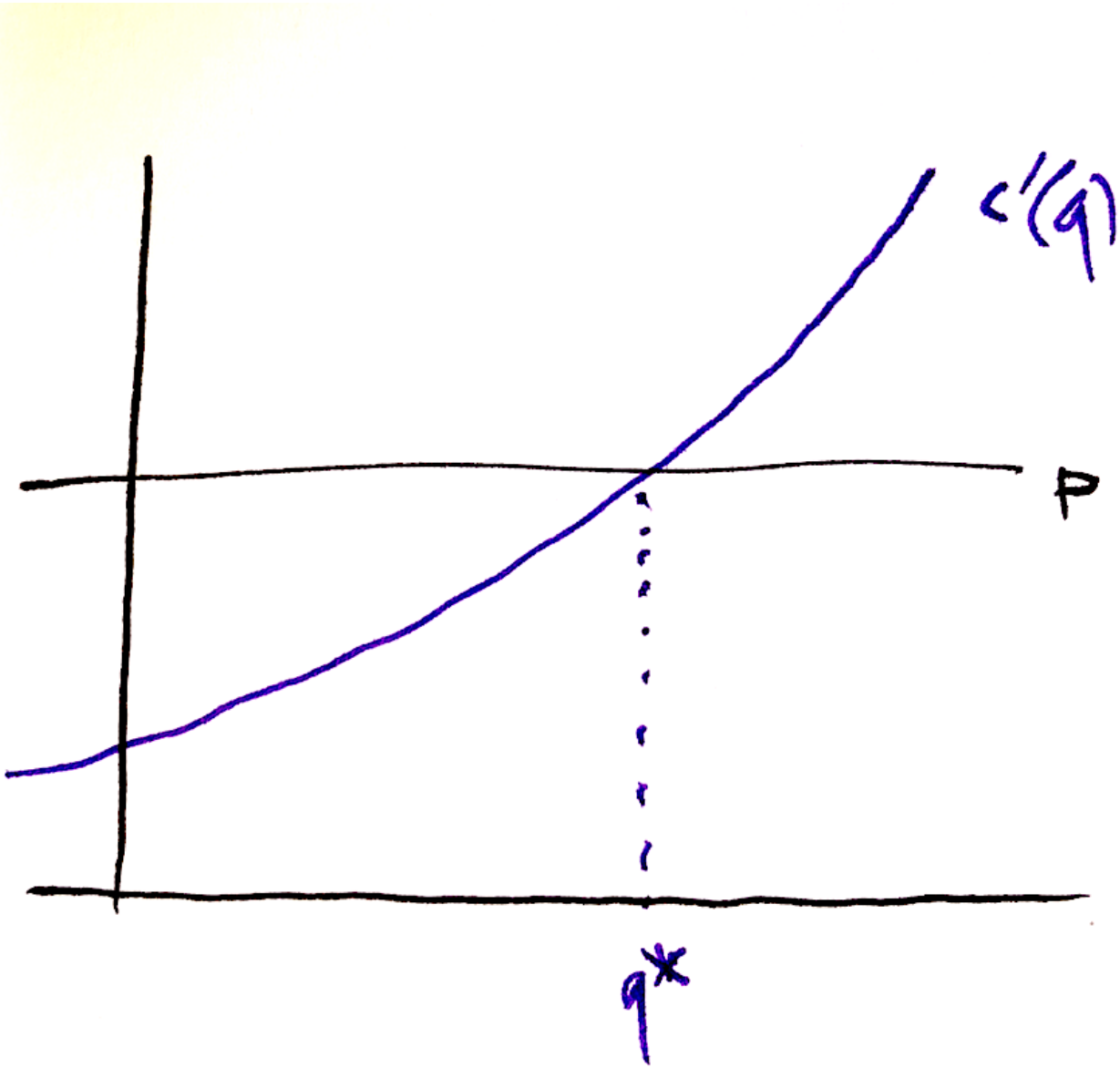
Free market equilibrium



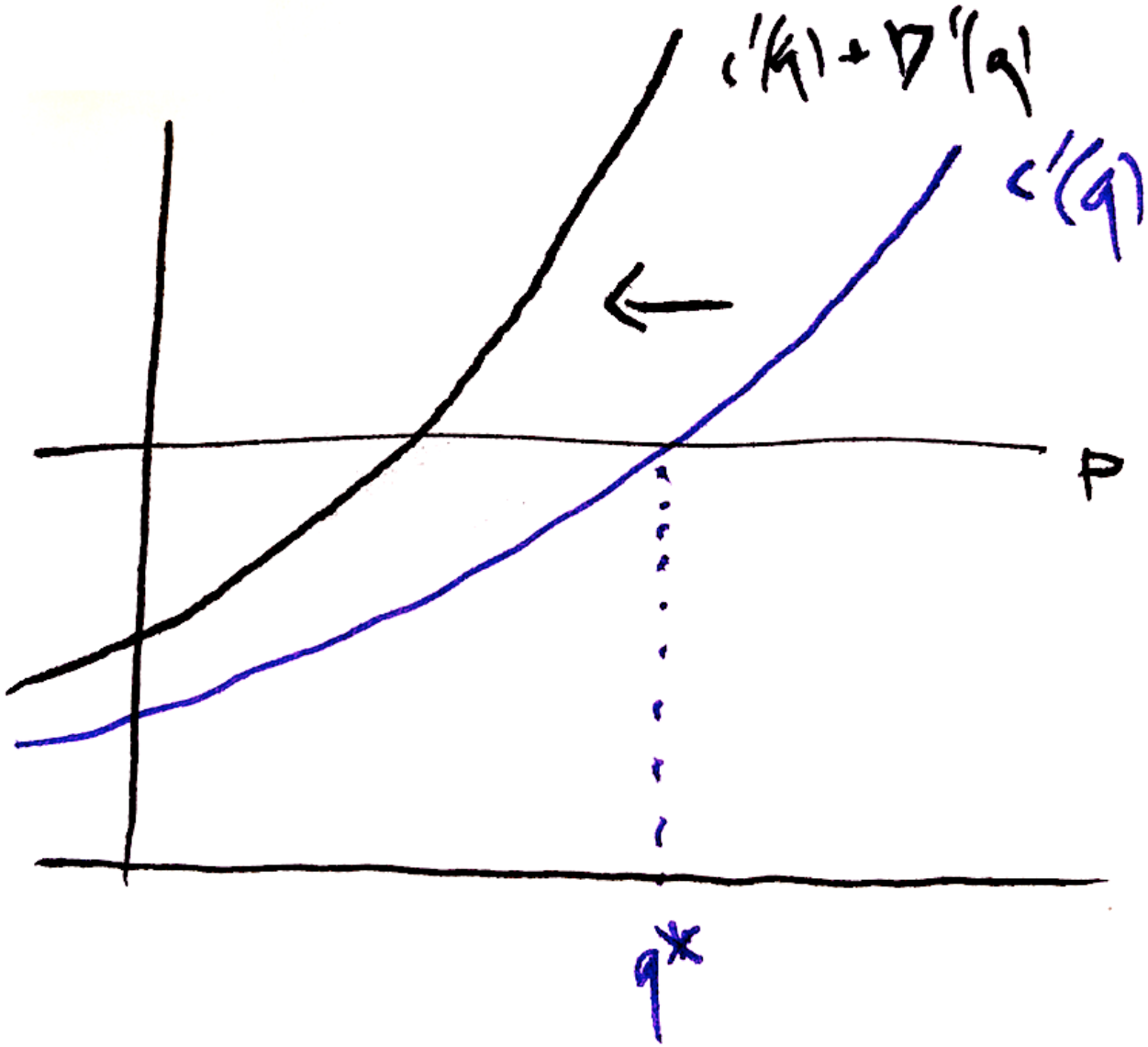
Free market equilibrium



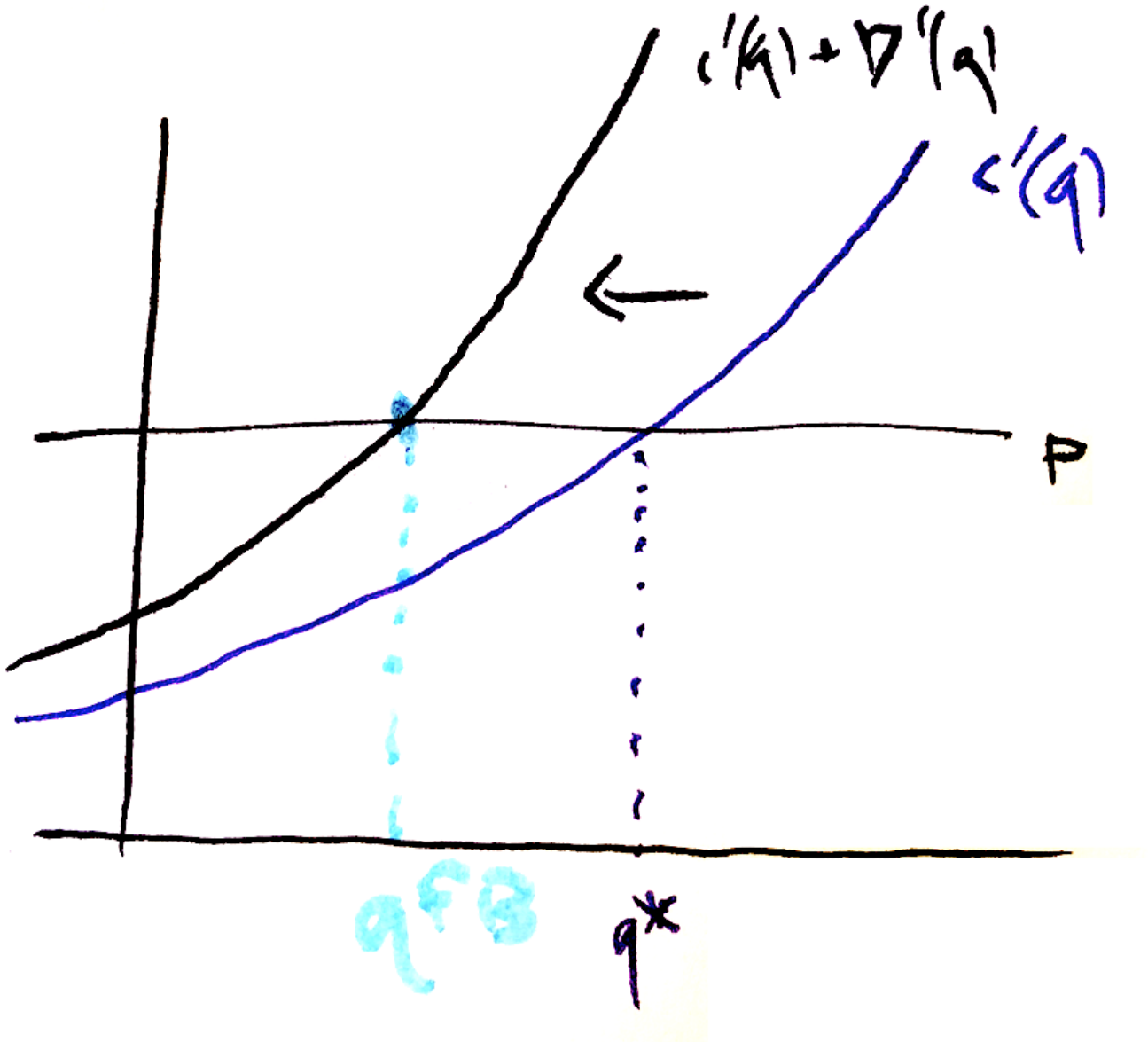
Free market equilibrium



Efficient outcome



Efficient outcome



Diagnosing market failure

Results so far:

Our Remark 1 was that

$$W(q^*) < W(q^{FB}),$$

because $q^* > q^{FB}$ (the negative externality is overproduced) and the marginal social cost of q exceeds the firm's marginal private cost.

Our Remark 2 was that

$$\pi(q^*) > \pi(q^{FB}),$$

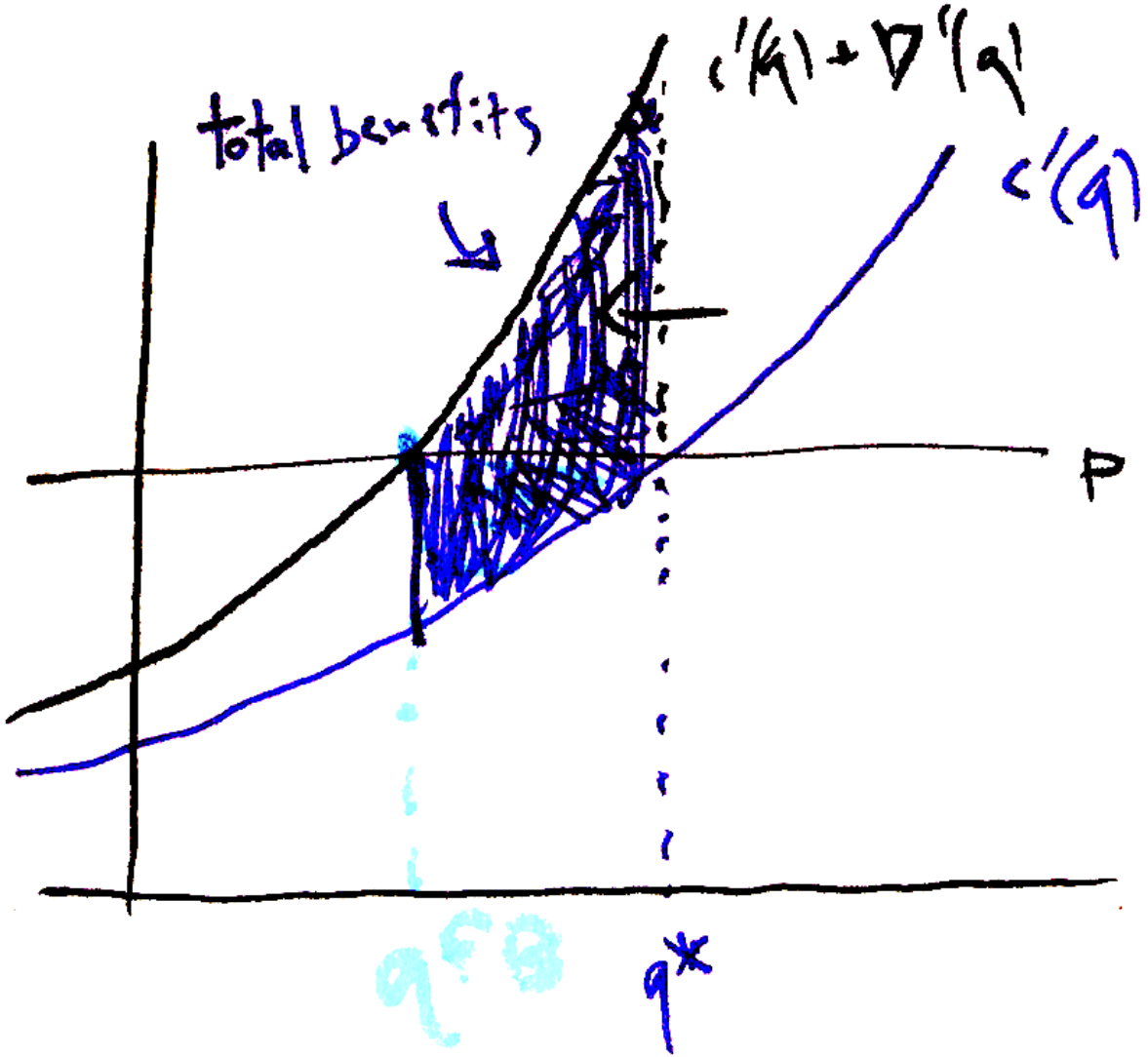
so the firm dislikes moving away from the free-market outcome.

Before, we said that Remark 1 implied the free market outcome is **inefficient**.

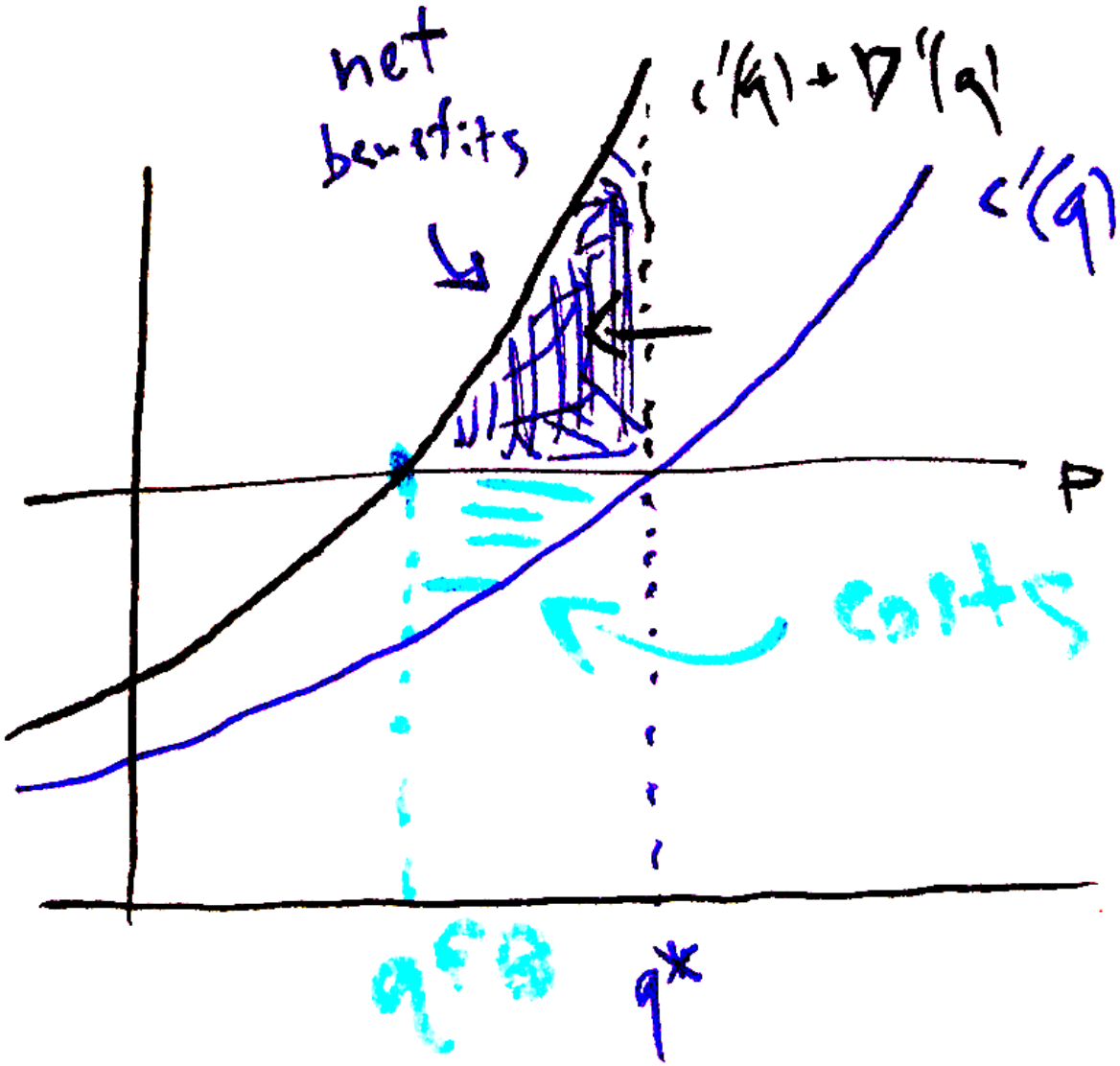
- Inefficient using our Kaldor-Hicks criterion!

We can also do the cost-benefit directly to show this.

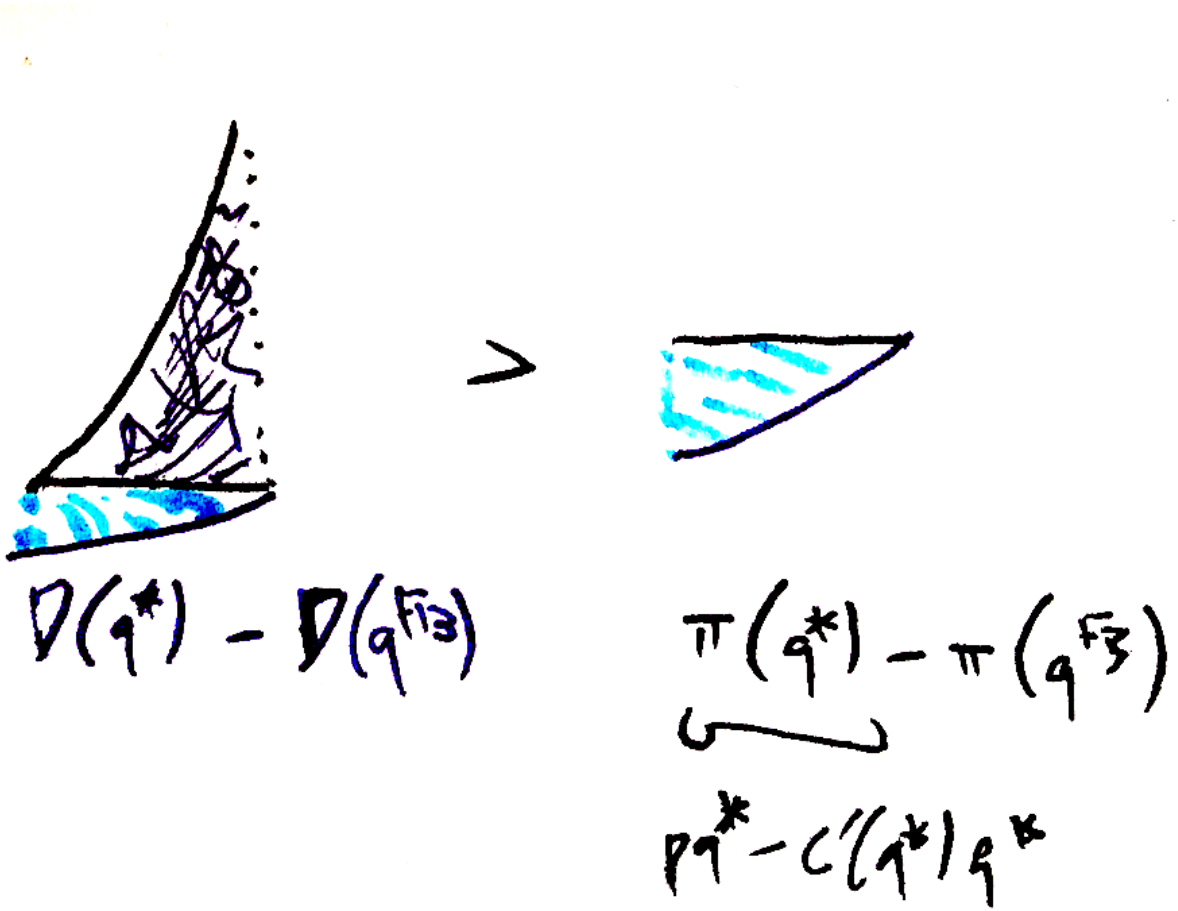
Interpretation as cost-benefit analysis



Interpretation as cost-benefit analysis



Interpretation as cost-benefit analysis



Society gains net benefits of

$$\Delta = \left[D(q^*) - D(q^{FB})\right] - \left[\pi(q^*) - \pi(q^{FB})\right] > 0$$

from moving away from the free market to the efficient outcome.

Policy solutions (1/4)

How can we restore efficiency?

The simplest and arguably trivial solution is to mandate that the firm produce q^{FB} instead of q^*.

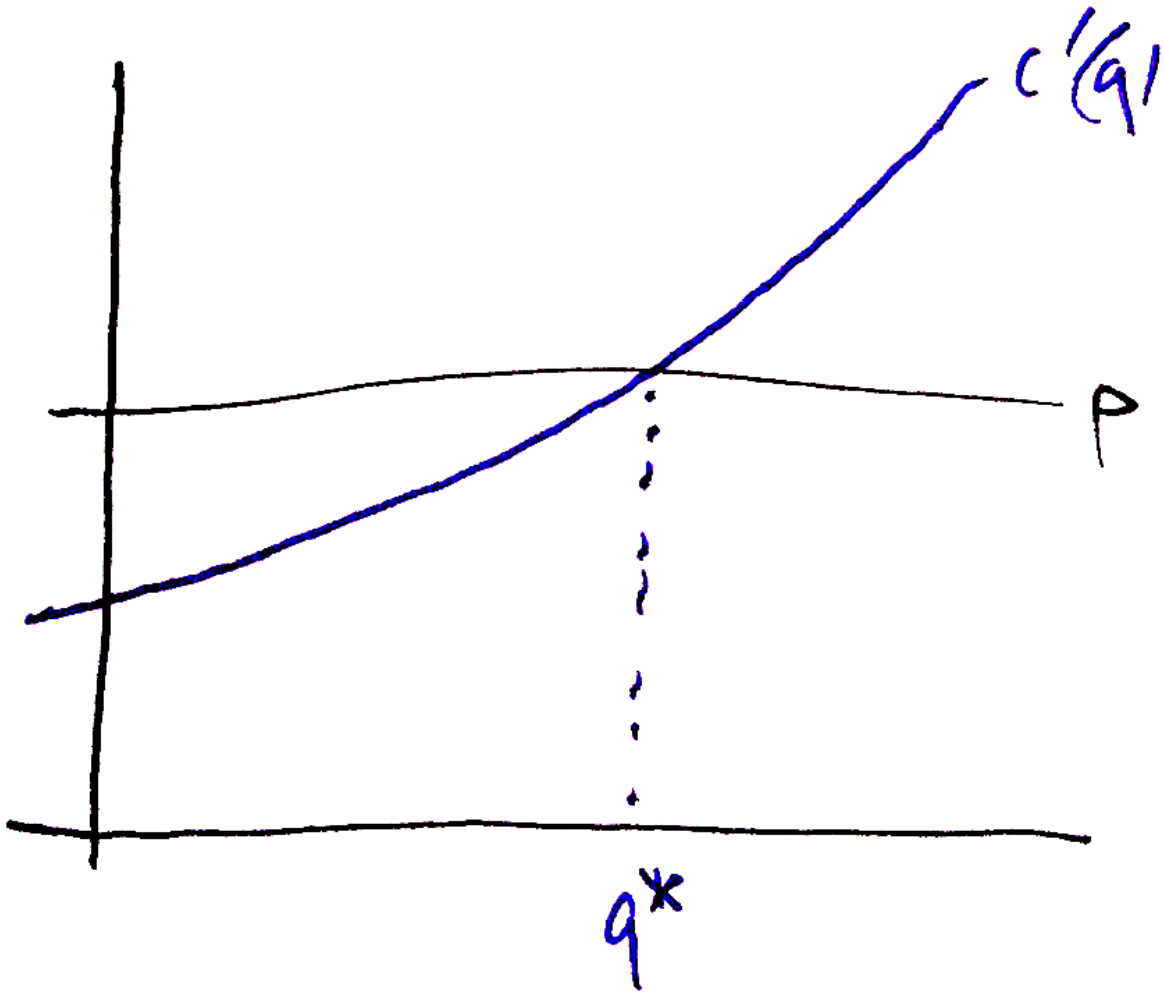
But rarely do we conscript producers. A less coercive rule achieves the same result:

Solution 1. Quantity regulation. Prohibit the firm from producing more than q^{FB}.

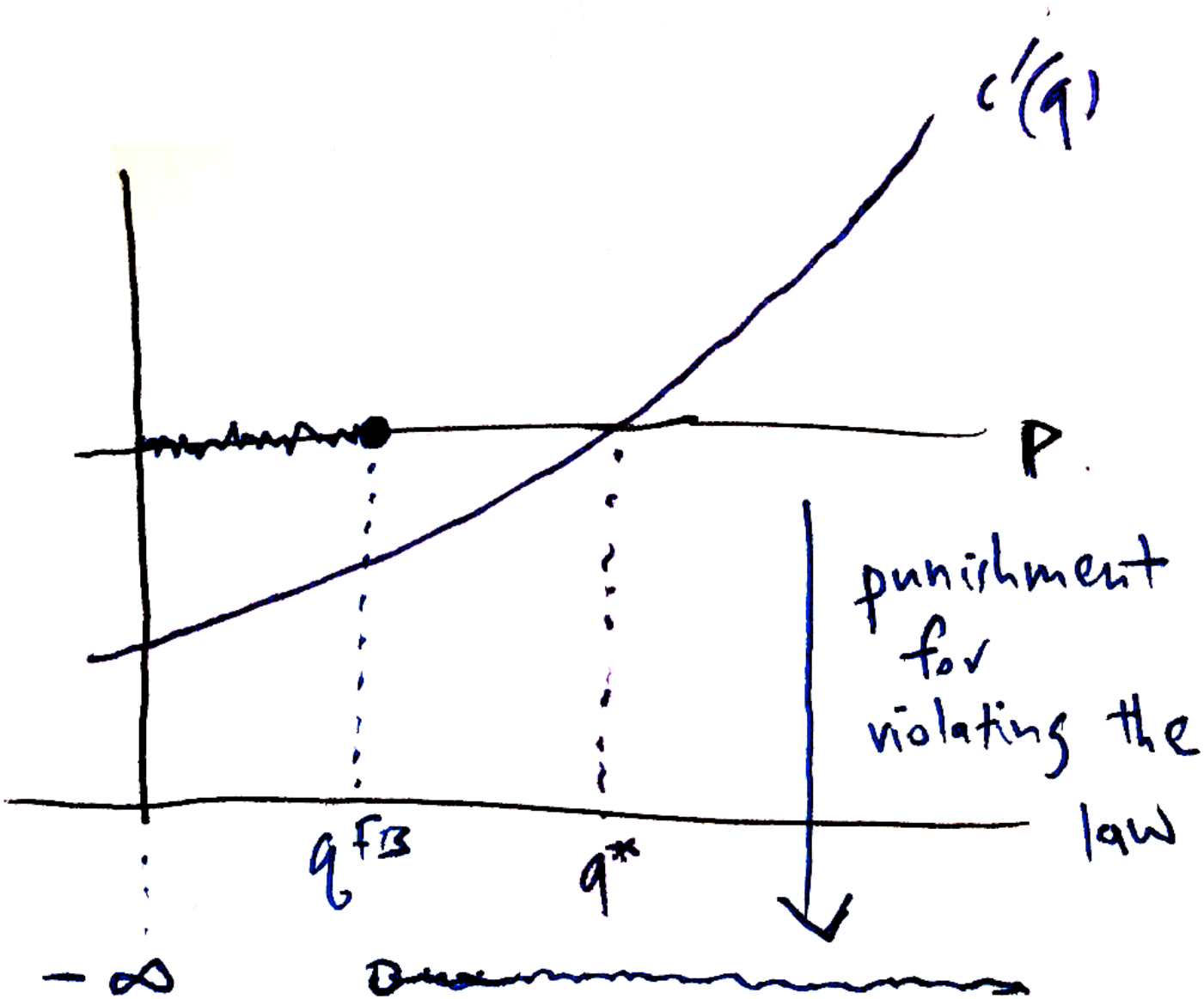
This imposes a "cap" on the firm's production. Note that, because $q^{FB} < q^*$, we know that $\pi'(q) > 0$ for all $q \leq q^{FB}$, so the firm will produce q^{FB}.

$\hookrightarrow$ we need not mandate that the firm produce exactly q^{FB}; the (regulated) market will take care of that!

Optimal quantity regulation



Optimal quantity regulation



Next time

- Next week, we will discuss three other approaches to solve externalities, then dive into some empirical questions: how (not) to estimate costs and benefits!
- Homework. Consider reading
  - Arrow et al. (1996). "Is there a role for cost-benefit analysis in environmental, health, and safety regulation?" Science, **272** (5259), 221–222.

  Consider skimming
  - Coase (1960). "The Problem of Social Cost," Journal of Law and Economics, **3**, October, 1–44.

  Links to these papers are posted on the course website.
- Problem Set 1 will be posted next Monday (10/6) after lecture, and is due before lecture the following Monday (10/13).