14.03 Microeconomic Theory & Public Policy, Fall 2022

Lecture slides 16 and 17: Externalities, the Coase Theorem, Traffic Congestion, and Hockey Helmets

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Externalities: Definition

An indirect *cost* or *benefit* to an uninvolved third party that arises as an effect of another party's (or parties') activity (source: Wikipedia, 2022/11/01)

- Externalities arise when an economic actor does not face the "correct price"
- Economic efficiency demands that *social* cost of marginal unit be equal to its *social* benefit
- If there are externalities, the *private* cost (benefit) of the marginal unit produced/consumed will not equal the marginal social cost (benefit)

Four Perspectives on Externalities

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   - Mass transit
   - Regulating pollution
4. Collective choice externalities: Hockey helmets

Externalities: A Simple Example

Suppose 400,000 commuters must take one of two routes between home and work:

1. Commute time bridge: $t_B(n_B) = 30 + n_B/20,000$ minutes
2. Commute time tunnel: $t_T(n_T) = 40 + n_T/5,000$ minutes

1. If commuters act in their own self interest, how many take each route, and what is the total travel time over all commuters? [What are commuters maximizing/minimizing?]

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$$n_B^d = 360,000, \quad n_T^d = 40,000$$
$$t_B^d = 48m, \quad t_T = 48m$$
$$\pi^d = 400,000 \times 48 = \mathbf{19,200,000}$$

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- *Is this likely to be socially efficient?*

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$$T_B = 47, \quad T_T = 52$$
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- The social planner's solution saves 100,000 minutes per day: 19,100,000 vs. 19,200,000

Mayor cannot direct individual commuters to the bridge or tunnel. But can impose a tax

3. Suppose commuters place a value of $6/hour on their time. Assuming that a toll is charged only on the bridge or tunnel, what toll implements the (socially optimal) outcome? [What problem does Mayor solve?]

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$$t = 0.10 \times [52 - 47]$$
$$t = 0.50$$

- Taxing the faster (bridge) route with a 0.50 toll would solve this problem
- Subsidizing the tunnel with a toll of 0.50 **bonus** (negative toll) would also solve this problem!

From `http://www.wsdot.wa.gov/Tolling/520/520tollrates.htm`
Seattle's SR 520 toll rates for cars and motorbikes (as of Nov 2020):

Monday - Friday	Good To Go! Pass	Pay By Mail
Midnight to 5 a.m.	$1.25	$3.25
5 a.m. to 6 a.m.	$2.00	$4.00
6 a.m. to 7 a.m.	$3.40	$5.40
7 a.m. to 9 a.m.	$4.30	$6.30
9 a.m. to 10 a.m.	$3.40	$5.40
10 a.m. to 2 p.m.	$2.70	$4.70
2 p.m. to 3 p.m.	$3.40	$5.40
3 p.m. to 6 p.m.	$4.30	$6.30
6 p.m. to 7 p.m.	$3.40	$5.40
7 p.m. to 9 p.m.	$2.70	$4.70
9 p.m. to 11 p.m.	$2.00	$4.00
11 p.m. to midnight	$1.25	$3.25

Why this allocation? Why this tax?

- Social planner equates **marginal — not average — social cost of last commuter over bridge vs. tunnel**

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- **These are equated when $n_B = 340,000$ and $n_T = 60,000$**

$$\frac{\partial \pi}{\partial B}|_{B=340,000}=30+2\times 17=64,\ \ \frac{\partial \pi}{\partial T}|_{T=60,000}=40+2\times 12=64$$

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- Notice that the optimal toll of $t = 0.50$ is *exactly equal to the marginal social net damage* from sending one more person over the bridge instead of the tunnel 65m - 60m. [Recall that commuters value one minute at $\$0.10$]

Externalities: Examples

- CO_2 emissions
- Water, air, noise pollution
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- Getting a COVID (or measles, or polio, etc.) vaccination
- Developing a valuable idea
- Being polite
- Carrying a licensed firearm?

The Coase Theorem

- Are externalities such as those above never internalized by the market?
- Until Ronald Coase's 1960 paper, "The Problem of Social Cost," most economists would have said yes
- Coase made them reconsider that view

"The Problem of Social Cost" Ronald Coase, 1960

*Let us first reconsider the case of Sturges v. Bridgman... In this case, a **confectioner** (in Wigmore Street) used two mortars and pestles in connection with his business (one had been in operation in the same position for more than 60 years and the other for more than 26 years). A **doctor** then came to occupy neighbouring premises (in Wimpole Street). The confectioner's machinery caused the doctor no harm until, eight years after he had first occupied the premises, he built a consulting room at the end of his garden right against the confectioner's kitchen. It was then found that the noise and vibration caused by the confectioner's machinery made it difficult for the doctor to use his new consulting room. "In particular . . . the noise prevented him from examining his patients by auscultations for diseases of the chest. He also found it impossible to engage with effect in any occupation which required thought and attention." The doctor therefore brought a legal action to force the confectioner to stop using his machinery. The courts had little difficulty in granting the doctor the injunction he sought. (Coase, 1960, pp 8-9)*

Is this reasoning complete?

- Baker's machinery disturbed the doctor's medical practice
- Doctor could not treat patients while the baker's machinery was running.
- The standard economic reasoning at the time, voiced by the court was
  - Baker should have to compensate the doctor for the harm his machinery was doing
  - Why? Baker's equipment was "causing" the externality
- Having the baker provide compensation would correct the externality imposed on the doctor

Coase's example revisited

- **You and your roommate share a room in an MIT dormroom**
  - You'd like to study for your 14.03 exam (one week from Monday, BTW!)
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- **Suppose**
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  - Your roommate's value of "making the rubble bounce" is V_M.
- **What's the "efficient" thing to do?**

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  - Does it matter for distribution?

Suppose MIT gives you the right to a quiet room

- If $V_Q > V_M$, you use that right and force your roommate to stop the music
- If $V_M > V_Q$, you should trade the right with your roommate: Any price $p \in (V_Q, V_M)$ will make you both strictly better off

$\implies$ Outcome is efficient

Suppose MIT gives your roommate the right to a loud room

- If $V_M > V_Q$, your roommate uses that right (and you are in trouble for your 14.03 exam...)
- If $V_Q > V_M$, your roommate should trade the right with you: any price $p \in (V_M, V_Q)$ will make you both strictly better off

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- The social planner does not need to know the private costs or benefits of the economic actors – does not have to measure the externality!
- Of course, the allocation of property rights still affects who bears the cost. So, it *matters* to whom we assign the property rights
- **This is the essence of the Coase theorem**

The Coase Theorem

The **Coase theorem** says that externalities get resolved essentially if: *(1) property rights are complete and (2) negotiating is costless.*

$\Longrightarrow$ to “solve” the externality, it is enough to create a market where property rights are being traded

- This market “internalizes” the externality
- Example: Rights for CO_2 emissions traded among countries
- Coasean solutions can be decentralized: there is no need for a social planner to know the details of each firm. Parties transact to price and resolve the externality

The Coase Theorem

- The Coase theorem is often **misinterpreted** to mean that the market **will** solve all externalities
- The correct interpretation of the Coase theorem is that the market can *potentially* solve externalities *if* property rights are clearly assigned *and* negotiation is feasible
- In some cases, negotiation is clearly infeasible
  - Airlines cannot realistically negotiate with individual homeowners for overflight rights to their houses
  - You cannot negotiate with all other drivers on the Mass Pike to get out of your way if you're in a hurry, even if you'd gladly pay them each $10 to pull over for a second

The Coase Theorem

- The problem of remedying externalities can be thought of as two separate problems:
  (1) *What* should be done (sound insulation, quiet machines)
  (2) *Who* should pay for it (doctor, baker?)
- The answer to the second question is independent of the the first. The first is about efficiency, the second about distribution (similar to shifting the endowment)
- As per the Second Welfare Theorem, the questions of how to maximize the economic pie and how to divide the pie are separable
- Both questions matter – but there is not a tradeoff between them
- Key insight: *Resolving an externality may not require regulating the externality out of existence (or even at all) but rather assigning property rights so that affected parties can achieve an efficient resolution*

Externalities: Part II

1. Externalities from mass transit
2. Regulating pollution: Three approaches
3. Externalities with social interactions: Hockey helmets

Example 1: Measuring Externalities from Mass Transit

Anderson, 2014 *AER*

Mass transit is expensive

- Mass transit attracts a disproportionate share of public funds but carries a negligible fraction of commuters
- In Washington, DC—which, until recently, had the second-busiest metro system in the United States—transit accounts for only 5 percent of passenger miles traveled
- In 2010, public transit received 23 percent of federal highway and transit outlays but accounted for 1 percent of passenger miles traveled
- In 2010, state, local, and federal subsidies exceed $40 billion per year and covered 63% of operating costs and 100% of capital costs

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3. Public transit pollutes less
4. Public transit reduces urban congestion, generating positive externalities for non-riders

Idea: Measure external benefits of public transit by studying transit strike

- October 2003 strike by Los Angeles County Metropolitan Transportation Authority (MTA) workers income commuters
- Strike lasted 35 days and shut down MTA bus and rail lines. Using hourly data on traffic speeds for all major Los Angeles freeways
- Study effects on congestion on highways that public transit users would *counterfactually* have taken
- Research design: Regression Discontinuity (RD) in date of strike start/stop

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- Alternative theories?
- *Perhaps people ride mass transit to avoid driving on the most congested roads!*
- **From an externalities perspective, does it matter?**

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- But for some, the Freeway is faster, for others, Public transit is faster

$$\left(Y_F - Y_P\right) \sim U\left[-0.5, 0.5\right]$$

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$$E[Y_F | Y_P] = Y_P$$

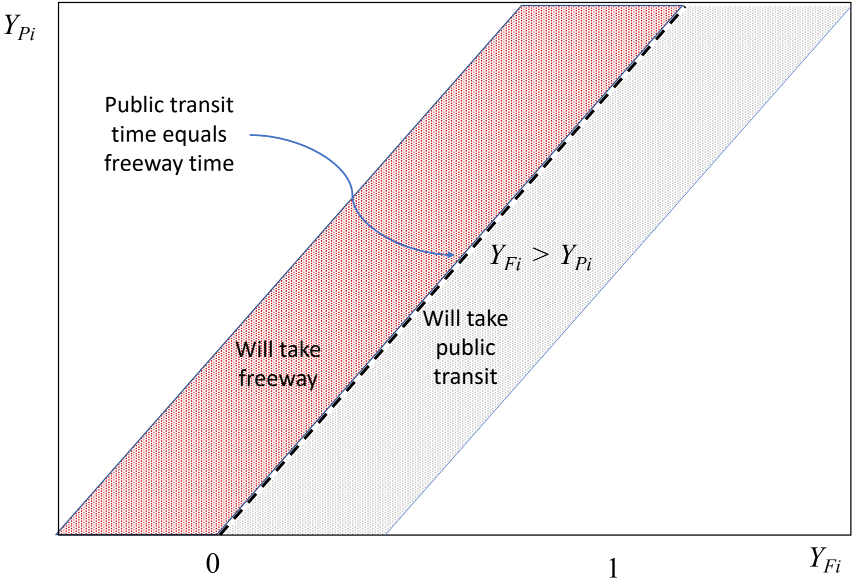
- But for some, the Freeway is faster, for others, Public transit is faster

$$(Y_F - Y_P) \sim U[-0.5, 0.5]$$

- Each commuter takes the fastest option

$$Y_i = \begin{cases} Y_{Fi} & \text{if} \quad Y_{Fi} \leq Y_{Pi} \\ Y_{Pi} & if \quad Y_{Fi} > Y_{Pi} \end{cases}$$

Who will take public transmit?



Expected Freeway commuting time of Public transit commuters?

- So, under normal conditions, Public transit commuters are those with slower than average Freeway routes, which likely means that these routes are congested

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$$\begin{aligned} E[Y_{Fi}|Y_{Fi} > Y_{Pi}] &= \int_0^1 Y_P \partial Y_P + E[Y_F - Y_P|(Y_F - Y_P) > 0] \\ &= 0.5 + 0.25 \\ &= 0.75 \end{aligned}$$

Key prediction

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- One likely reason for this is that Public transit commuters' Freeway routes are congested
- Implication: the transit strike will make Freeway conditions *much worse*—even though only a small share of commuters uses Public transit
- Adding more commuters to *already congested* roads slows throughput (vehicle miles traveled (VMT) per hour). Once a road exceeds optimal carrying capacity, more cars equals fewer VMT/hr

Los Angeles major public transit routes and freeways

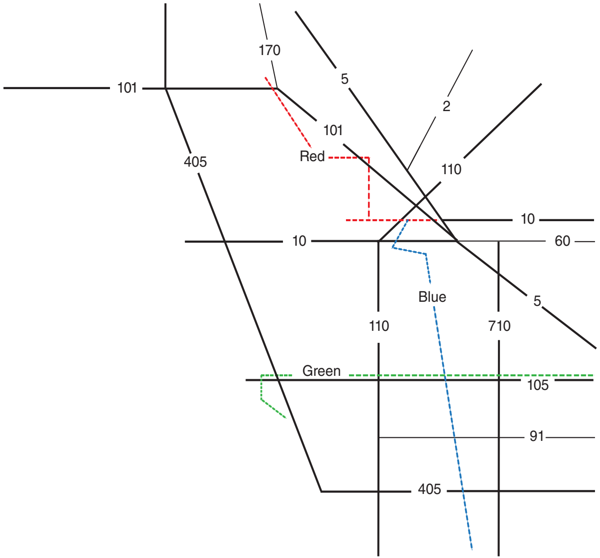

FIGURE 1. LOS ANGELES FREEWAYS AND RAIL LINES, 2003

Key Regression Discontinuity evidence

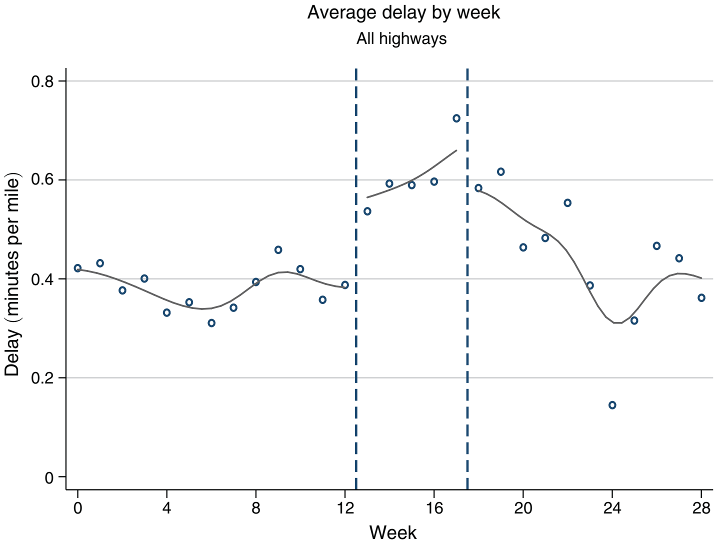

FIGURE 2. WEEKLY PEAK HOUR DELAY ON MAJOR LOS ANGELES FREEWAYS, 7/14/2003 TO 1/30/2004

Results for major freeways

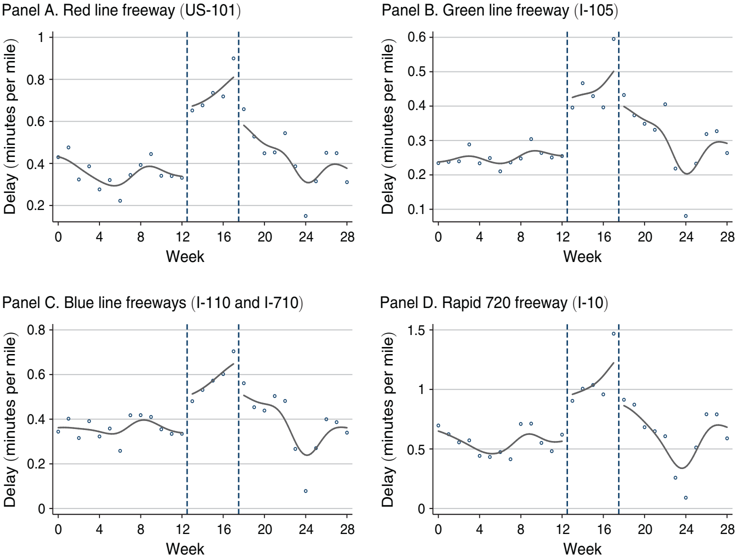

Figure 3. Average Weekly Peak Hour Delay on Specific Los Angeles Freeways, 7/14/2003 to 1/30/2004

Falsification exercise: Effects on highways not in LA MTA service area

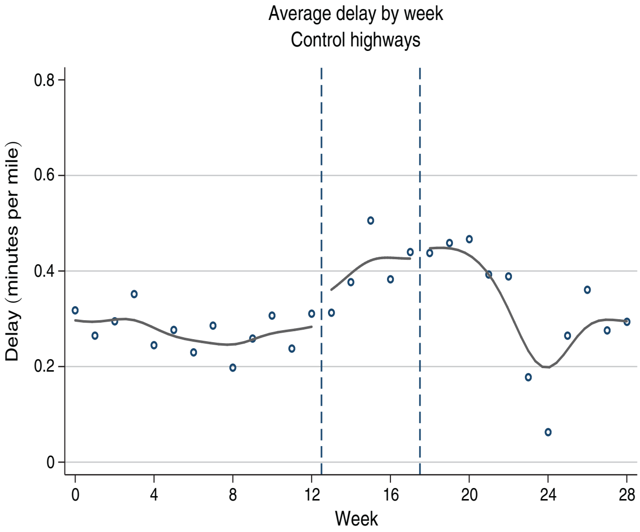

FIGURE 5. WEEKLY PEAK HOUR DELAY ON ORANGE/VENTURA COUNTY FREEWAYS, 7/14/2003 TO 1/30/2004

Delays per minute during peak hours

TABLE 4—EFFECT OF STRIKE ON DELAYS DURING ALL PEAK HOURS

Average delay (in minutes per mile)	(1)	(2)	(3)	(4)	(5)	(6)
Strike	0.194	0.332	0.218	0.190	0.357	0.125
	(0.041)	(0.076)	(0.052)	(0.051)	(0.128)	(0.042)
Date	−0.004	−0.003	−0.002	−0.003	−0.005	−0.005
	(0.002)	(0.003)	(0.002)	(0.002)	(0.004)	(0.002)
Date × strike	0.007	0.006	−0.001	0.007	0.012	0.007
	(0.002)	(0.003)	(0.002)	(0.003)	(0.007)	(0.002)
Average delay prestrike	0.409	0.369	0.264	0.357	0.600	0.434
Freeways	All	101	105	110 and 710	10	Other
Parallel transit line		Red line	Green line	Blue line	Rapid 720	
Sample size	178,549	15,854	31,058	19,152	15,357	97,128

Notes: Each column represents a separate VMT-weighted regression, with weights equal to (length of highway covered by detector i) × (average prestrike traffic flow over detector i). The observation is the detector-hour, and the sample is limited to weekdays from 7–10 AM and 2–8 PM within 28 days of the strike's beginning. Parentheses contain clustered standard errors that are robust to within-day and within-detector serial correlation. All regressions include day-of-week and detector fixed effects.

Delays per minute during peak morning hours

TABLE 5—EFFECT OF STRIKE ON DELAYS DURING PEAK MORNING HOURS

Average delay (in minutes per mile)	(1)	(2)	(3)	(4)	(5)	(6)
Strike	0.314	0.482	0.283	0.189	0.619	0.258
	(0.075)	(0.148)	(0.090)	(0.073)	(0.179)	(0.079)
Date	−0.003	−0.003	0.003	−0.002	−0.013	−0.003
	(0.003)	(0.005)	(0.002)	(0.004)	(0.009)	(0.004)
Date × strike	0.000	−0.005	−0.012	0.008	0.010	0.001
	(0.005)	(0.007)	(0.004)	(0.006)	(0.012)	(0.005)
Average delay prestrike	0.472	0.392	0.268	0.485	0.953	0.464
Freeways	All	101	105	110 and 710	10	Other
Parallel transit line		Red line	Green line	Blue line	Rapid 720	
Sample size	58,380	5,210	10,136	6,214	5,074	31,746

Notes: Each column represents a separate VMT-weighted regression, with weights equal to (length of highway covered by detector i) × (average prestrike traffic flow over detector i). The observation is the detector-hour, and the sample is limited to weekdays from 7–10 AM within 28 days of the strike's beginning. Parentheses contain clustered standard errors that are robust to within-day and within-detector serial correlation. All regressions include day-of-week and detector fixed effects.

Delays per minute during peak evening hours

TABLE 6—EFFECT OF STRIKE ON DELAYS DURING PEAK AFTERNOON HOURS

Average delay (in minutes per mile)	(1)	(2)	(3)	(4)	(5)	(6)
Strike	0.157	0.266	0.213	0.197	0.279	0.085
	(0.040)	(0.064)	(0.061)	(0.056)	(0.132)	(0.049)
Date	−0.005	−0.004	−0.005	−0.004	−0.004	−0.006
	(0.002)	(0.003)	(0.002)	(0.002)	(0.005)	(0.002)
Date × strike	0.010	0.011	0.005	0.007	0.017	0.011
	(0.002)	(0.004)	(0.002)	(0.002)	(0.008)	(0.002)
Average delay prestrike	0.384	0.361	0.274	0.300	0.401	0.431
Freeways	All	101	105	110 and 710	10	Other
Parallel transit line		Red line	Green line	Blue line	Rapid 720	
Sample size	120,007	10,575	20,922	12,938	10,283	65,289

Notes: Each column represents a separate VMT-weighted regression, with weights equal to (length of highway covered by detector i) × (average prestrike traffic flow over detector i). The observation is the detector-hour, and the sample is limited to weekdays from 2–8 PM within 28 days of the strike's beginning. Parentheses contain clustered standard errors that are robust to within-day and within-detector serial correlation. All regressions include day-of-week and detector fixed effects.

Effects on occupancy—vehicle directly over sensor

TABLE 7—EFFECT OF STRIKE ON FREEWAY OCCUPANCY

Average share of time detector is occcupied	(1)	(2)	(3)	(4)	(5)	(6)
Strike	0.013	0.023	0.019	0.016	0.022	0.008
	(0.003)	(0.006)	(0.004)	(0.004)	(0.009)	(0.003)
Date	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Date × strike	0.000	0.000	0.000	0.000	0.001	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Average share of time detector is occupied prestrike	0.112	0.121	0.097	0.115	0.129	0.110
Freeways	All	101	105	110 and 710	10	Other
Parallel transit line		Red line	Green line	Blue line	Rapid 720	
Sample size	179,680	16,222	31,112	19,152	15,668	97,526

Notes: Each column represents a separate VMT-weighted regression, with weights equal to (length of highway covered by detector i) × (lanes at detector i). The observation is the detector-hour, and the sample is limited to weekdays from 7–10 AM and 2–8 PM within 28 days of the strike's beginning. Parentheses contain clustered standard errors that are robust to within-day and within-detector serial correlation. All regressions include day-of-week and detector fixed effects.

Effects on traffic flow—throughput of roadways

TABLE 8—EFFECT OF STRIKE ON TRAFFIC FLOWS

Hourly traffic flow per lane	(1)	(2)	(3)	(4)	(5)	(6)
Strike	−31.3	−68.2	−9.4	−1.4	−61.1	−29.4
	(9.7)	(17.3)	(11.7)	(18.1)	(19.6)	(9.0)
Date	0.81	0.79	0.91	0.46	1.14	0.83
	(0.40)	(0.58)	(0.62)	(0.94)	(0.88)	(0.33)
Date × strike	−1.85	−2.50	−1.29	−2.46	−2.45	−1.53
	(0.61)	(0.85)	(0.73)	(1.07)	(1.06)	(0.60)
Average hourly flow prestrike	1,399	1,576	1,349	1,403	1,455	1,353
Freeways	All	101	105	110 and 710	10	Other
Parallel transit line		Red line	Green line	Blue line	Rapid 720	
Sample size	179,680	16,222	31,112	19,152	15,668	97,526

Notes: Each column represents a separate VMT-weighted regression, with weights equal to (length of highway covered by detector i) × (lanes at detector i). The observation is the detector-hour, and the sample is limited to weekdays from 7–10 AM and 2–8 PM within 28 days of the strike's beginning. Parentheses contain clustered standard errors that are robust to within-day and within-detector serial correlation. All regressions include day-of-week and detector fixed effects.

Traffic time-shifting in response to delays

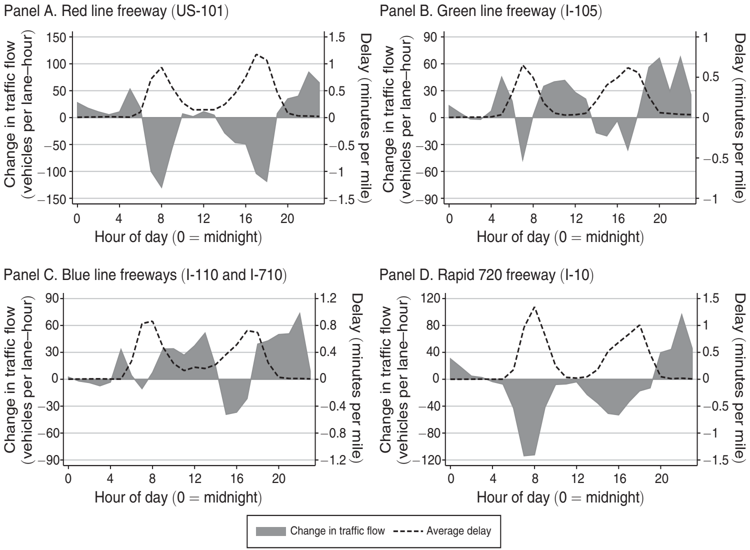

FIGURE 4. CHANGES IN TRAFFIC FLOWS BY HOUR OF DAY ON SPECIFIC LOS ANGELES FREEWAYS

A tiny fraction of commuters use public transmit: Is it worth the cost?

Benefits in dollars

- An increase of 0.19 minutes per mile in traffic delays in Los Angeles implies an aggregate increase of **114 million hours of delay per year**
- Conservatively assumes that transit has no effect on arterial road congestion

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Benefits per public transmit Passenger Mile (PM)

- LA MTA carried approximately 1 billion PM during peak hours in 2003
- Congestion relief benefit per peak-hour transit PM is $1.20 – $2.16 per PM

Cost-benefit analysis of public transit investments

Table 11—Capital Investment Benefits

	Baseline	Low ridership growth	High bus ridership	"Extreme" VMT elasticity
Fixed parameters				
2001 ridership (Red, Green, Blue lines)	69 million	—	—	—
2010 ridership (Red, Green, Blue lines)	85 million	—	—	—
Share of ridership that is peak hour	57 percent	—	—	—
2010 rail operating subsidy ($2003)	$115 million	—	—	—
Annual real wage growth	1 percent	—	—	—
Real discount rate	5 percent	—	—	—
Short-run congestion relief benefit per peak mile	$2.50	—	—	—
Varying parameters				
Annual ridership growth (to max of 175 million)	1.7 million	0.9 million	—	—
Share riders retained if replacing rail with bus	26 percent	—	50 percent	—
2010 operating subsidy if replacing rail with bus	$126 million	—	$215 million	—
VMT elasticity w.r.t. total travel costs	−1.5	—	—	−2.0
Long-run congestion relief benefit per peak mile	$1.61	—	—	$1.50
Total costs and benefits				
Capital cost of rail system	$7.1 billion	$7.1 billion	$7.1 billion	$7.1 billion
Present value of gross benefits	$13.7 billion	$11.8 billion	$12.3 billion	$12.7 billion
Present value of net benefits	$6.6 billion	$4.8 billion	$5.2 billion	$5.7 billion

Notes: Cell entry of "—" indicates cell contains same value as baseline column. All dollar figures are expressed in 2003 US$ for comparability. Ridership figures and operating subsidies come from LACMTA reports. Real wage growth comes from BLS (2006), and real discount rate comes from US Department of Transportation (2003).

Example 2: Remedying Pollution

Example: Remedying Pollution

- Two oil refineries produce fuel, which has a market price of $\$3$ per gallon. Demand is infinitely elastic.
- Each refinery uses $\$2$ in raw inputs (crude oil, energy, labor) to produce 1 gallon of fuel
- Each plant produces smog, which creates $\$0.01$ of environmental damage per CF. Assume each plant can produce 200 gallons.
- The amount of smog *per gallons of fuel* produced differs at the two plants:

$$\begin{aligned} s_1 &= y_1^2, \\ s_2 &= \frac{1}{2}y_2^2, \end{aligned}$$

where y_1, y_2 denote the number of gallons of fuel produced at each plant.

Question: What happens in this competitive case without pollution regulation?

Example: Remedying Pollution — Competitive outcome

- Profit maximization problem:

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- Profit maximization problem:

$$\begin{aligned}
\max_{y_1}\ \pi_1 &= y_1 \cdot (3-2)\ s.t.\ y_1 \leq 200, \\
\max_{y_2}\ \pi_2 &= y_2 \cdot (3-2)\ s.t.\ y_2 \leq 200, \\
y_1^* &= y_2^* = 200.
\end{aligned}$$

- Each firm ignores the social damage from its smog production (notice that s_1, s_2 do not enter into the firms' profit maximization problems). Pollution is $s_1 = 40,000$, $s_2 = 20,000$. The negative pollution externality is $\$400$ and $\$200$ from plants 1 and 2

Example: Remedying Pollution — Competitive outcome

- Profit maximization problem:

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- Social surplus is consumers' willingness to pay for output ($\$3$ per gallon) minus the resource costs of production minus the social costs of smog output:

$$(200 + 200) \times (3 - 2) - 0.01 \times (40,000 + 20,000) = -200$$

Example: Remedying Pollution — Socially Efficient Outcome

- To get socially efficient level, equate marginal social benefit to marginal social cost
  - What is the social benefit? It is $\$3$.
  - The marginal social cost of production is $\$2$ in raw inputs *plus* the cost of pollution.
  - The efficiency condition is $MB_s = MC_s$,

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- At the margin, there should be no more than $\$1$ of environmental damage per gallon of fuel produced, so no plant should produce more than 100 CF of smog per gallon of fuel
- Imagine that each plant faced the social costs of production. Could rewrite the previous profit maximization as:

$$\begin{aligned}
\max_{y_1} \pi_1 &= y_1 \cdot (3-2) - 0.01y_1^2 \quad s.t.\ y_1 \leq 200, \\
\max_{y_2} \pi_2 &= y_2 \cdot (3-2) \ - \frac{1}{2} \cdot 0.01y_2^2 \ \ s.t.\ y_2 \leq 200
\end{aligned}$$

Example: Remedying Pollution — Socially Efficient Outcome

- To get socially efficient level, equate marginal social benefit to marginal social cost
  - What is the social benefit? It is $3.
  - The marginal social cost of production is $2 in raw inputs *plus* the cost of pollution.
  - The efficiency condition is $MB_s = MC_s$,
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\max_{y_2} \ \pi_2 &= y_2 \cdot (3-2) \ - \frac{1}{2} \cdot 0.01 y_2^2 \ \ s.t.\ y_2 \leq 200
\end{aligned}$$

$$y_1^{**} = 50, \ y_2^{*} = 100.$$

Example: Remedying Pollution — Socially Efficient Outcome

- When Plant 1 is producing 50 gallons, the marginal gallon produces 100 CF of smog, which causes $\$1.00$ in environmental damage
- More pollution than this would be socially inefficient since fuel sells for $\$3$ and uses $\$2$ in raw inputs to produce
- For Plant 2, corresponding production is 100 gallons because this plant produces less smog per gallon
- What is the social surplus from output in this case?

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- What is the social surplus from output in this case?

$$(100 + 50) \times (3 - 2) - 0.01 \times \left(\frac{1}{2} \times 100^2 + 50^2 \right) = \$75$$

- We now have an efficient benchmark for welfare maximization.
- How do we get plants to produce the socially efficient level of pollution? Three classes of regulatory solution are possible. Each has different properties.

Example: Remedying Pollution — Command and Control Regulation

- Command and control regulation is the traditional approach to limiting externalities
- Sets numerical *quantity* limits on activities that have external effects. Often called quantity regulation.
- Most common command and control regulation is simply banning an activity
- This is generally not efficient (though straightforward)
- Much command-control allows *some* amount of activity, but less than private actor would choose
- How does this apply above? We know the optimal quantity of production for each plant
- Could pass law: "Plant 1 and Plant 2 may produce 50 and 100 gallons respectively" that regulate the behavior of each plant individually. Also difficult to modify these laws as technology or pollution costs change

Comparison: Three Externality Regulation Schemes

	Command and Control	Pigouvian Taxation	Cap and Trade
Information Requirements			
Firm Incentives			
Regulatory Risks			
Regulatory Costs			

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	Command and Control	Pigouvian Taxation	Cap and Trade
Information Requirements	Prod'n function for each firm		
Firm Incentives	Conceal costs; No marginal incentive to abate		
Regulatory Risks	Inefficient production; Lack of innovation		
Regulatory Costs			

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- Achieves desired result with arguably less complexity than command/control
- This case is simplified by assumption that the marginal damage of pollution is constant $\$0.01$ per CF

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- The Pigouvian tax idea does not use the Coase theorem
- It aligns private and social costs by taxing the externality, thereby causing firms to internalize these costs
- Pigouvian tax does not create conditions for negotiation among firms
- Coase theorem suggests that we may be able to do even better
- If property rights are fully assigned, then the regulatory body should not, in theory, have to be involved
- Parties will negotiate among themselves to find the lowest cost solution to correcting the externality

Question: How can this insight be applied?

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- This motivates the idea of *allocating pollution rights.*
- Using algebra above, can calculate that the 'optimal amount of pollution' is $50^2 + \frac{1}{2}\left(100^2\right) = 7,500$ CF of smog.
- Instead of taxing pollution, the government could issue $7,500$ "permits to pollute" one CF each of smog
- Permits could be used by the permit holder to pollute, or could be sold by the permit holder to another refinery so it could pollute instead.

How will this work?

Example: Remedying Pollution — Assigning Property Rights

First, consider case where government holds an auction to sell permits:

- Environmental Protection Agency (EPA) announces an initial pollution permit price
- Each firm announces number of permits it would like to buy at that price
- The EPA compares the sum of these quantities to the available supply of $7,500$
- If the quantity demanded is less than $7,500$, the EPA lowers the price
- If the quantity demanded is above $7,500$, the EPA raises the price
- The EPA solicits a new set of demands
- Repeat until EPA has established the market clearing price

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- How much would each plant wish to bid at any price p_0?
- Calculate as follows for each plant:

$$\max_{s_1} \pi_1 = s_1^{\frac{1}{2}} (3 - 2) - p_0 s_1$$

$$s_1^* = \left(\frac{1}{2p_0} \right)^2$$

and

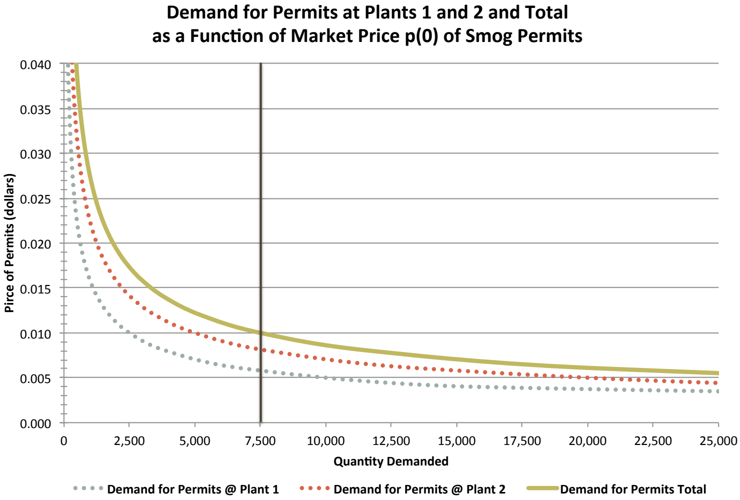
$$\max_{s_2} \pi_2 = (2s_2)^{\frac{1}{2}} (3 - 2) - p_0 s_2$$

$$s_2^* = \left(\frac{1}{\sqrt{2} p_0} \right)^2$$

- We've rewritten output of fuel in terms of smog permits used. Thus, for plant one $y_1 = s_1^{\frac{1}{2}}$, and for plant two $y_2 = (2s_2)^{\frac{1}{2}}$

Example: Remedying Pollution — Assigning Property Rights

Demand for permits as a function of price $s(p_0) = \left(\frac{1}{2p_0}\right)^2 + \left(\frac{1}{\sqrt{2}p_0}\right)^2$:



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2. Produce 100 gallons of fuel (pollution is $\frac{1}{2} \cdot 100^2 = 5000$)
    - Sell its $2,500$ remaining permits to Plant 1 at the market price
    - With $2,500$ permits, Plant 1 could produce 50 gallons of fuel (pollution will be $50^2 = 2,500$)
    - Since its profits are $\$1$ per gallon, it would pay up to $\$50$ for these permits
    - *Plant 2 would therefore make $\$150$ in profits by using $5,000$ permits and selling $2,500$ others*

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3. Plant 2 could also implement any mixture of these two options, including selling all of its permits to Plant 1. Demonstrate to yourself that Plant 2 cannot do better than the 2nd option above.

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3. It could keep $2,500$ permits and sell $5,000$ to Plant 2.
    - Profits would be $\$150$
    - Plant 1 would produce 50 gallons
    - Plant 2 would produce 100 gallons and pay up to $\$100$ for the privilege.

Comparison of the three methods

- Done right, command and control, Pigouvian taxation, and cap and trade each produce efficient outcomes
- But they are not identical from a regulatory perspective
- Command and control regulation requires intimate knowledge of the production structure of each plant. It is cumbersome to implement and to get right
- The Pigouvian taxation has the advantage that plants will optimally choose the level of pollution that maximizes their profits, including the cost of the Pigouvian tax. However, it requires knowledge of the marginal social cost of pollution

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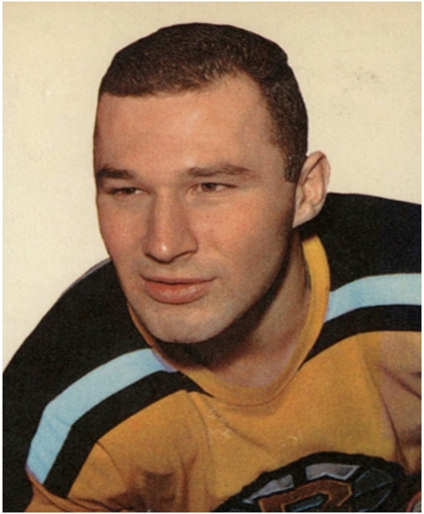
Externalities with Social Interactions

Thomas Schelling, *Micromotives and Macrobehavior*, 1978

Sep 21, 1969 – Wayne Maki of St. Louis Blues Strikes Ted Green of Bruins in the Head with a Stick

- Green suffered a fractured skull and brain damage
- Doctors diagnosed a depressed fracture of the skull near the right temple
- Five hours of brain surgery, a metal plate in his head, and a subsequent brain operation, saved his life
- Green missed the rest of the season and returned the following season



The Next Day

"When I saw the way that Teddy Looked, it was an awful feeling. I'm going to start wearing a helmet now, and I don't care what anyone says."

– Don Awrey, fellow Bruins player

A few days later

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- He ordered them to put on the helmets or get off the ice
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- Head down, Orr skated off the ice, followed by his teammates
- Schmidt decided not to make an issue of it and the helmets were stored away

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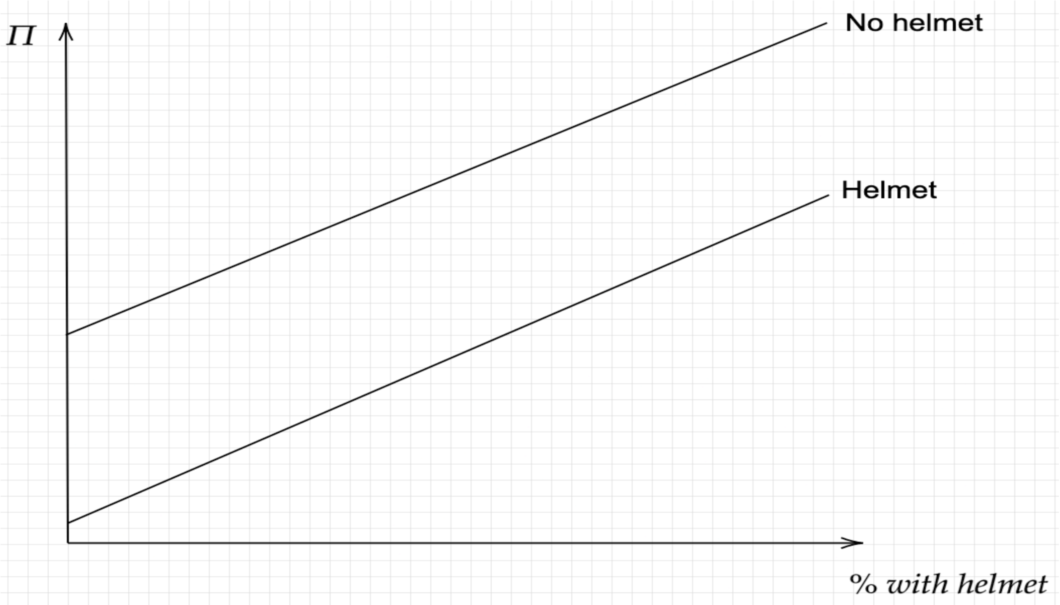
- In August 1979, NHL mandated that protective helmets would become mandatory for all *incoming* NHL players. *Incumbents were grandfathered*
- The last player to play without a helmet was Craig MacTavish, who played his final game in **1997** for the St. Louis Blues

Who will wear a hockey helmet?



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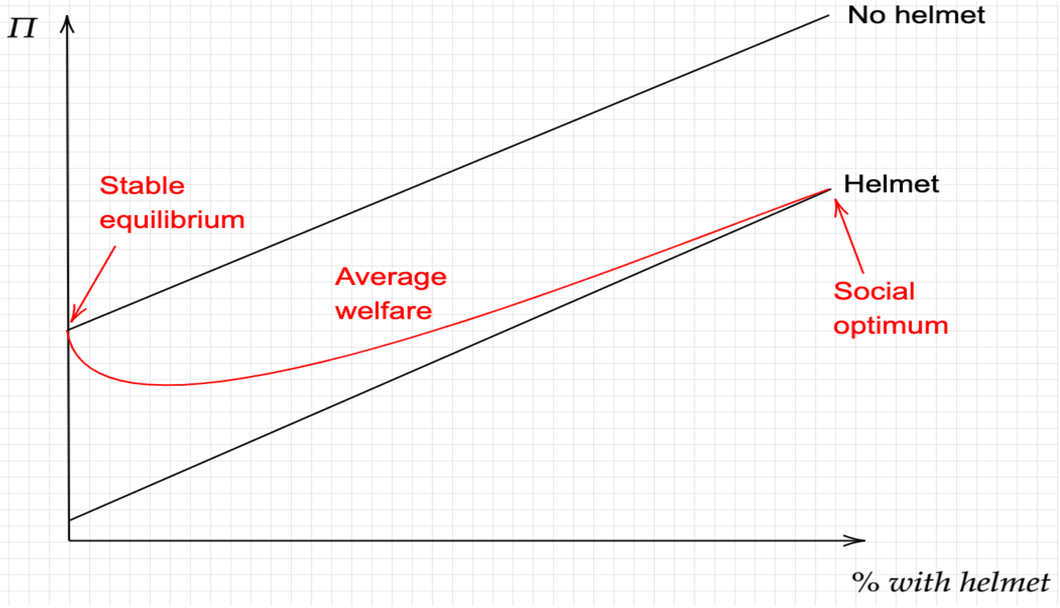
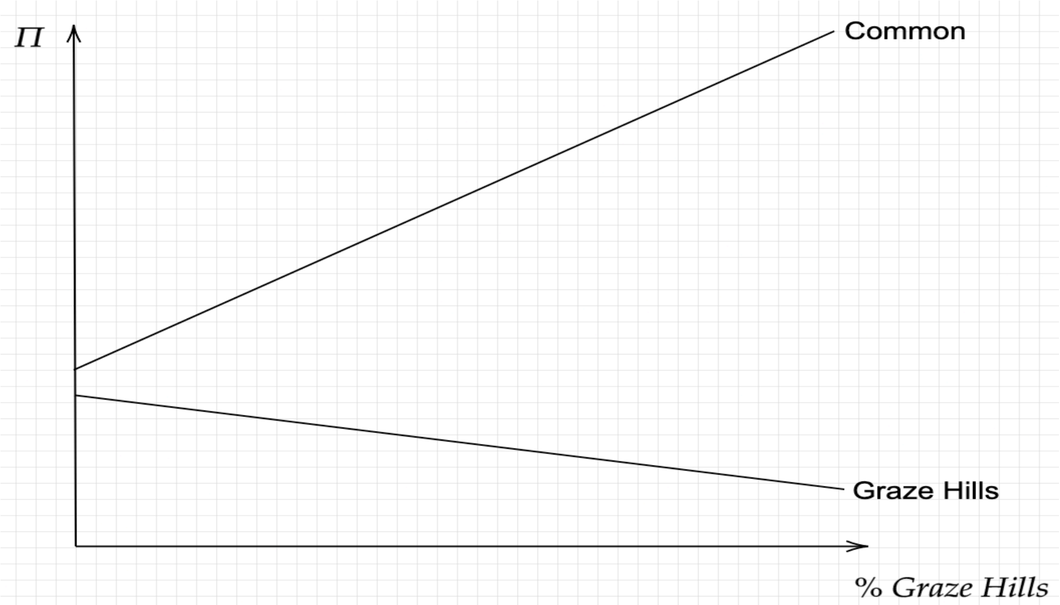


Tragedy of the commons: Graze the common or the hills?



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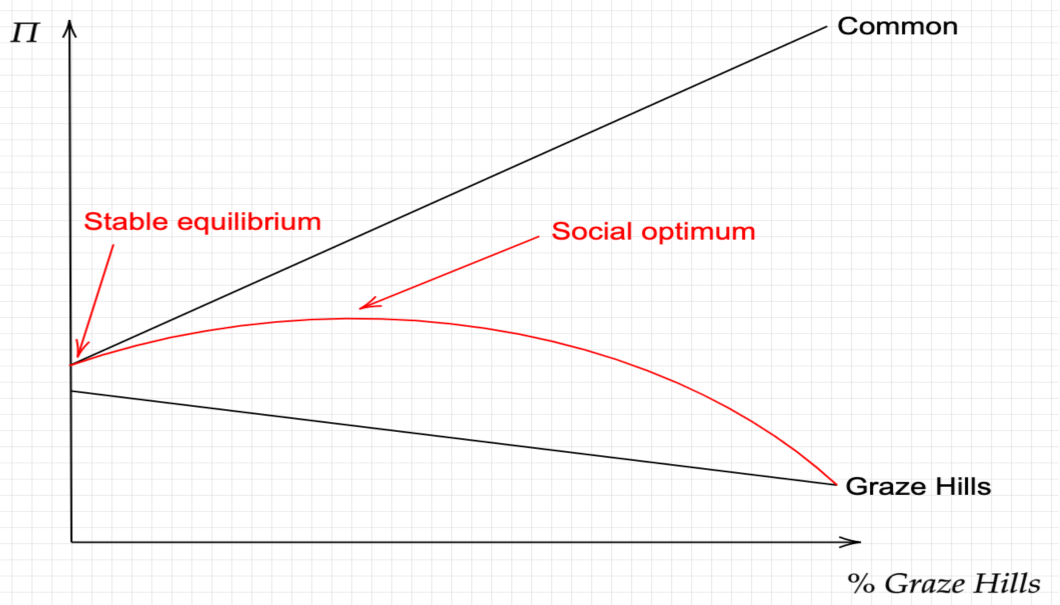

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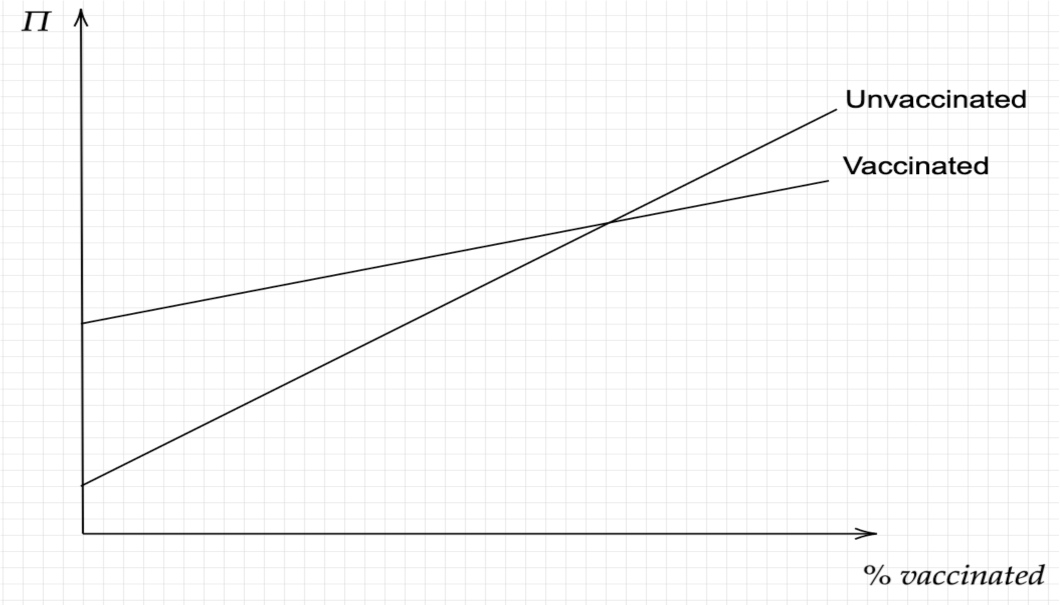

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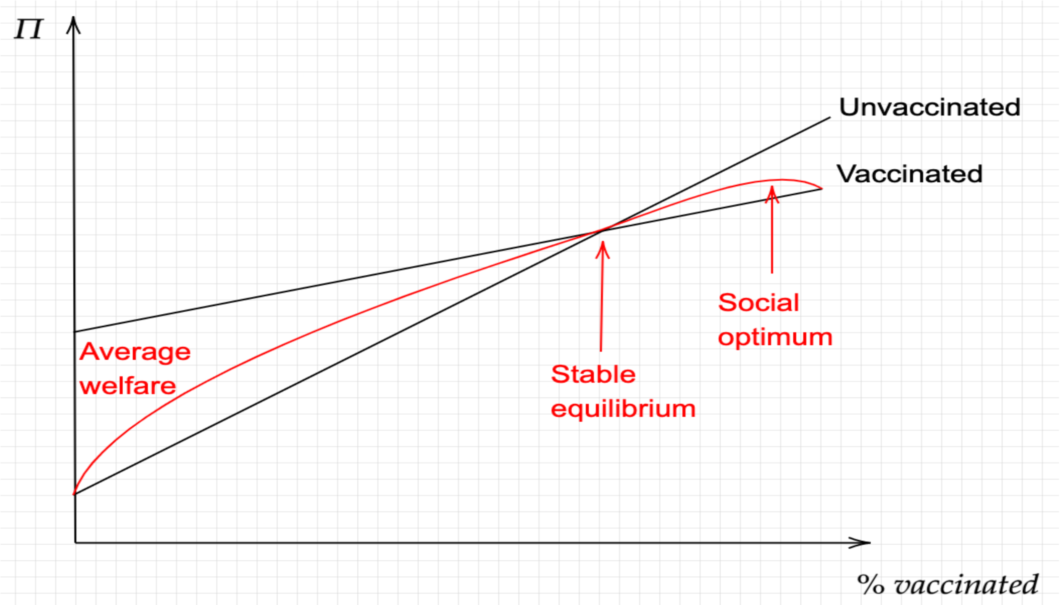
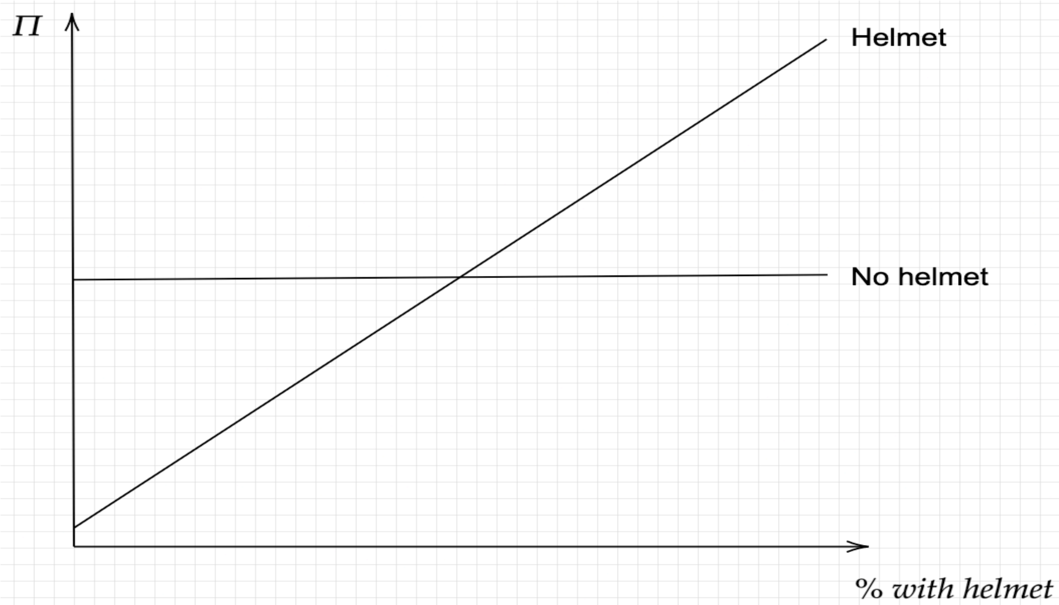


Should you wear a ski helmet?



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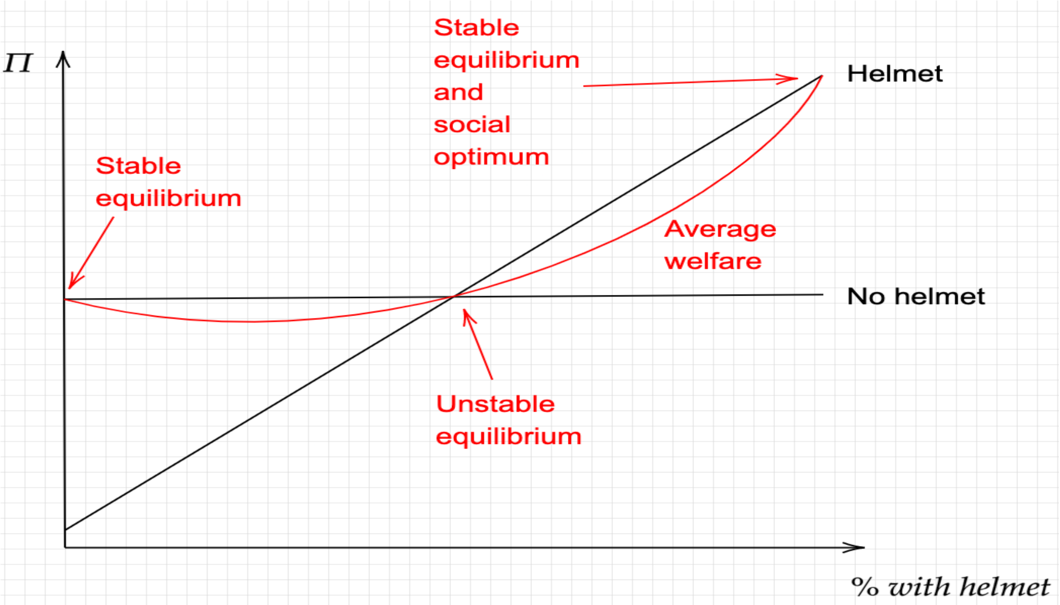
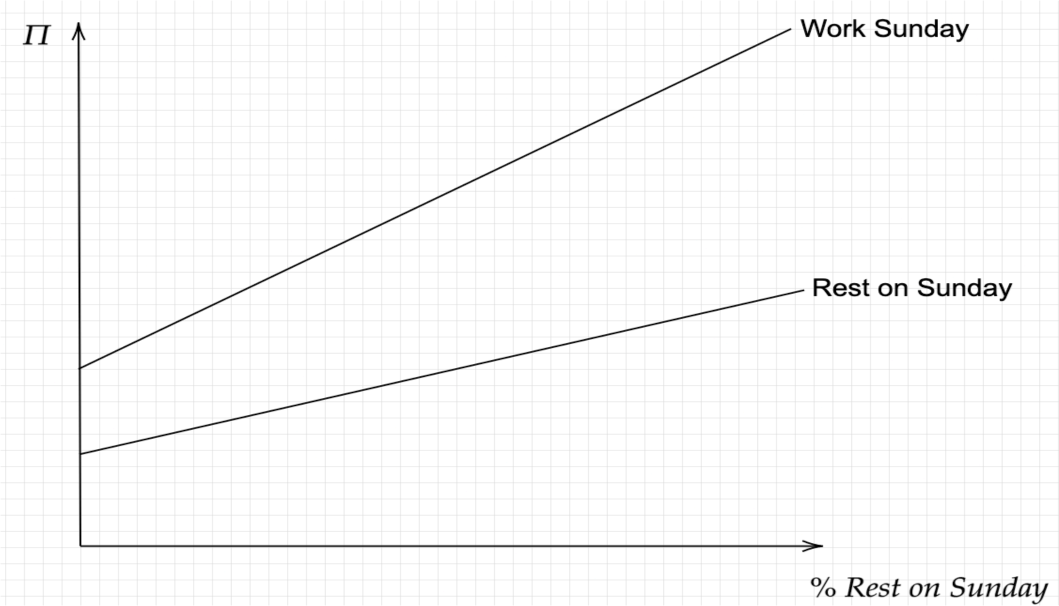


Should you work on Sunday?



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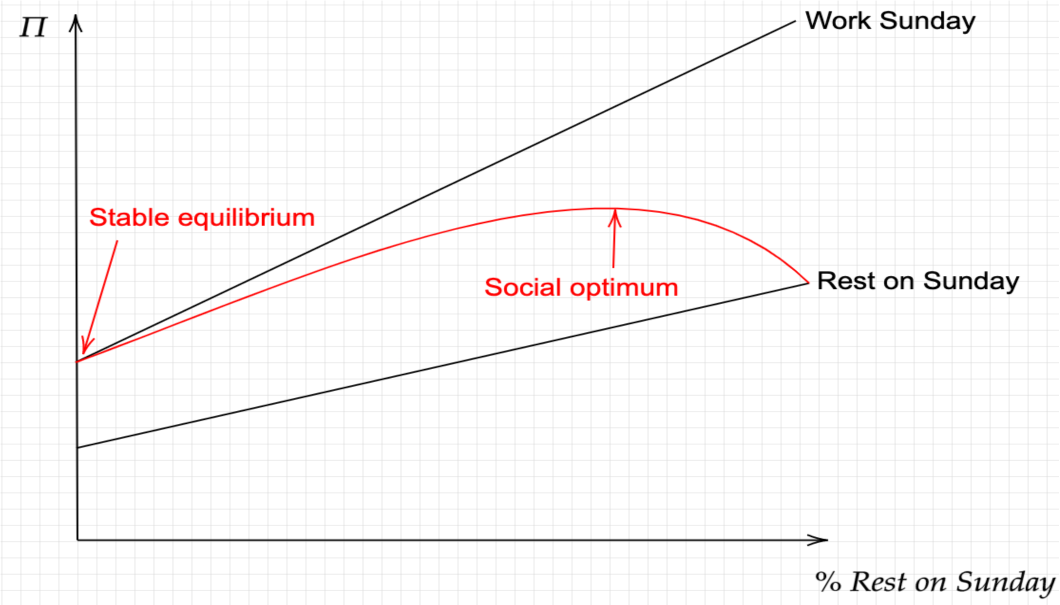

Should an MIT professor be a tough grader?