Public Economics: Lecture 4
Externalities & Internalities

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Socially efficient allocation

Think about demand/supply in a market in terms of private vs. social costs/benefits

- Private marginal cost (PMC): the direct costs to producers of creating an additional unit of a good (i.e. the supply curve)
- Social marginal cost (SMC): the PMC plus any other per-unit production costs imposed on others
- Private marginal benefit (PMB): the direct benefit to consumers of consuming an additional unit of a good (i.e. the demand curve)
- Social marginal benefit (SMB): the PMB minus the marginal costs imposed on others through consumption of the good

- At the socially efficient allocation: $SMC = PMC$ and $SMB = PMB$

Externalities

- Externalities occur when a party making a decision does not internalize the cost/benefit of their actions for another party
- This is a market failure because private and social incentives diverge – either $SMC \neq PMC$, $SMB \neq PMB$, or both
- Uninternalized costs/benefits are called the marginal damage (MD) of the action causing the externality

- An externality can be represented graphically as either a production or consumption externality (matter of interpretation)
- Negative externalities lead to overproduction, while positive externalities lead to underproduction

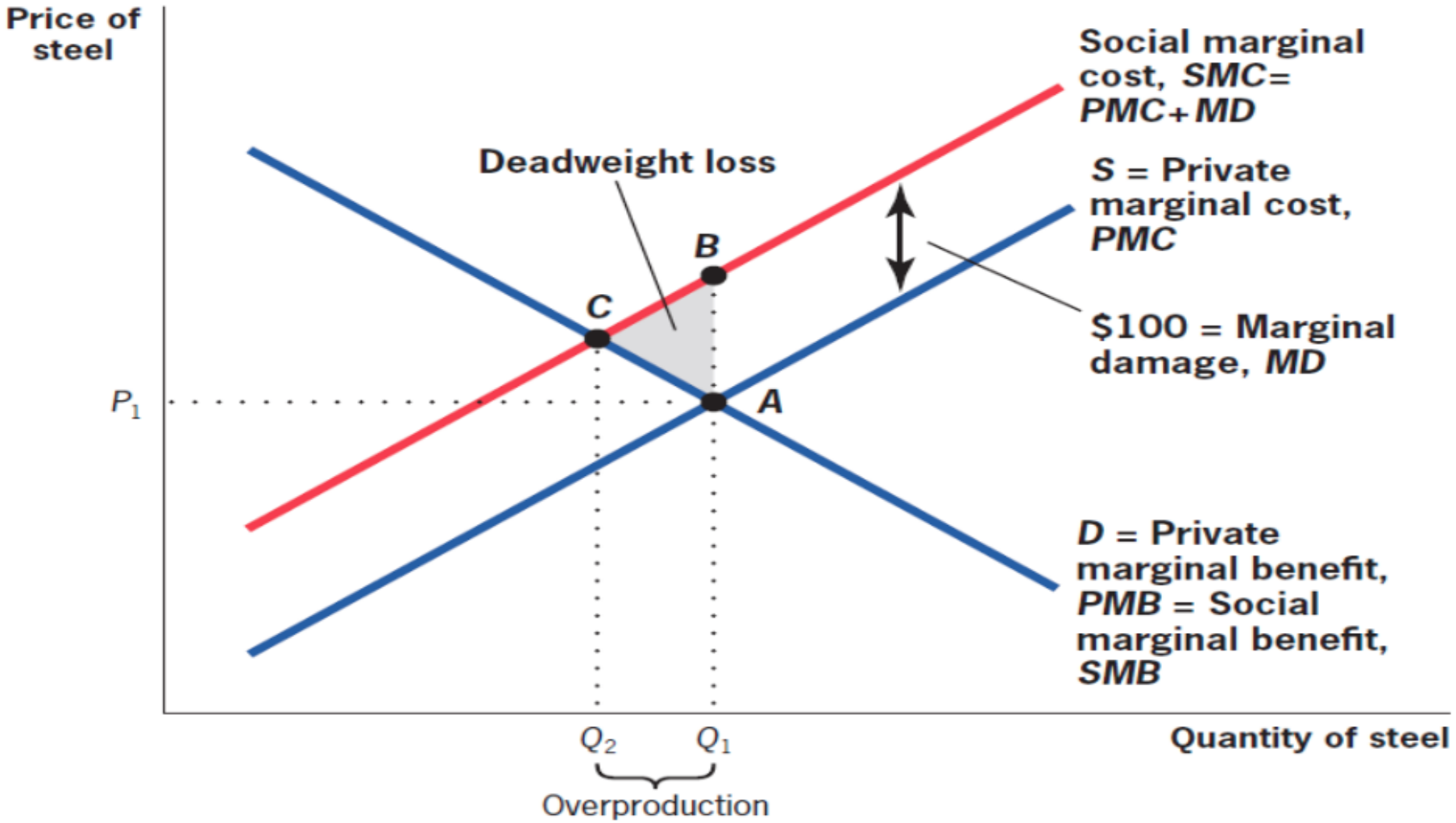
Real vs. pecuniary externalities

- Important distinction between real and pecuniary externalities
- Pecuniary externality – one party does not take into account the effects of their actions on market prices
  - Example: Russian oligarchs buy up luxury apartments in Manhattan, driving housing prices up and preventing local residents from buying
- Only real externalities are market failures – there are costs/benefits not reflected in market prices
  - Example: steel plant that pollutes a river used for recreation (pollution, or having a clean river, is unpriced)
- Since we are interested in motivations for government intervention, in this course the focus is entirely on real externalities

Types of externalities

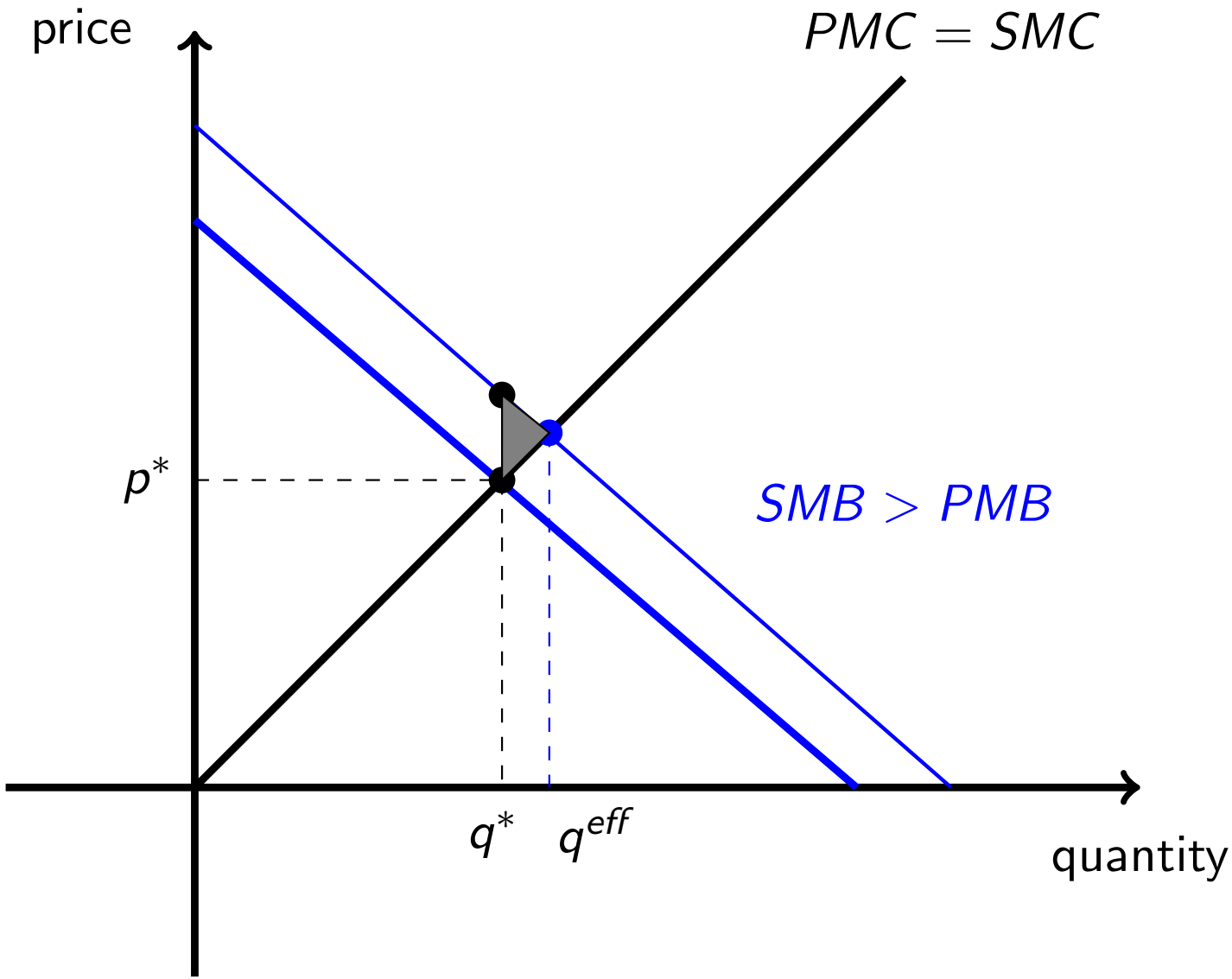
1. Negative production externalities: $SMC > PMC$, $Q^* > Q^{eff}$
   - Example: a pharmaceutical company does not take into account the social cost of dumping waste chemicals into a nearby river
2. Positive production externalities: $SMC < PMC$, $Q^* < Q^{eff}$
   - Example: the same company fails to take into account the added social benefit of funding R&D for orphan drug treatments
3. Negative consumption externalities: $SMB < PMB$, $Q^* > Q^{eff}$
   - Example: alcohol drinkers fail to internalize the added social cost of increase risk of accidents while intoxicated
4. Positive consumption externalities: $SMB > PMB$, $Q^* < Q^{eff}$
   - Example: parents fail to take into account the added social benefit of reduced disease transmission from childhood vaccines

Negative production externality – illustration



Source: Gruber, *Public Finance and Public Policy*, Figure 5.2

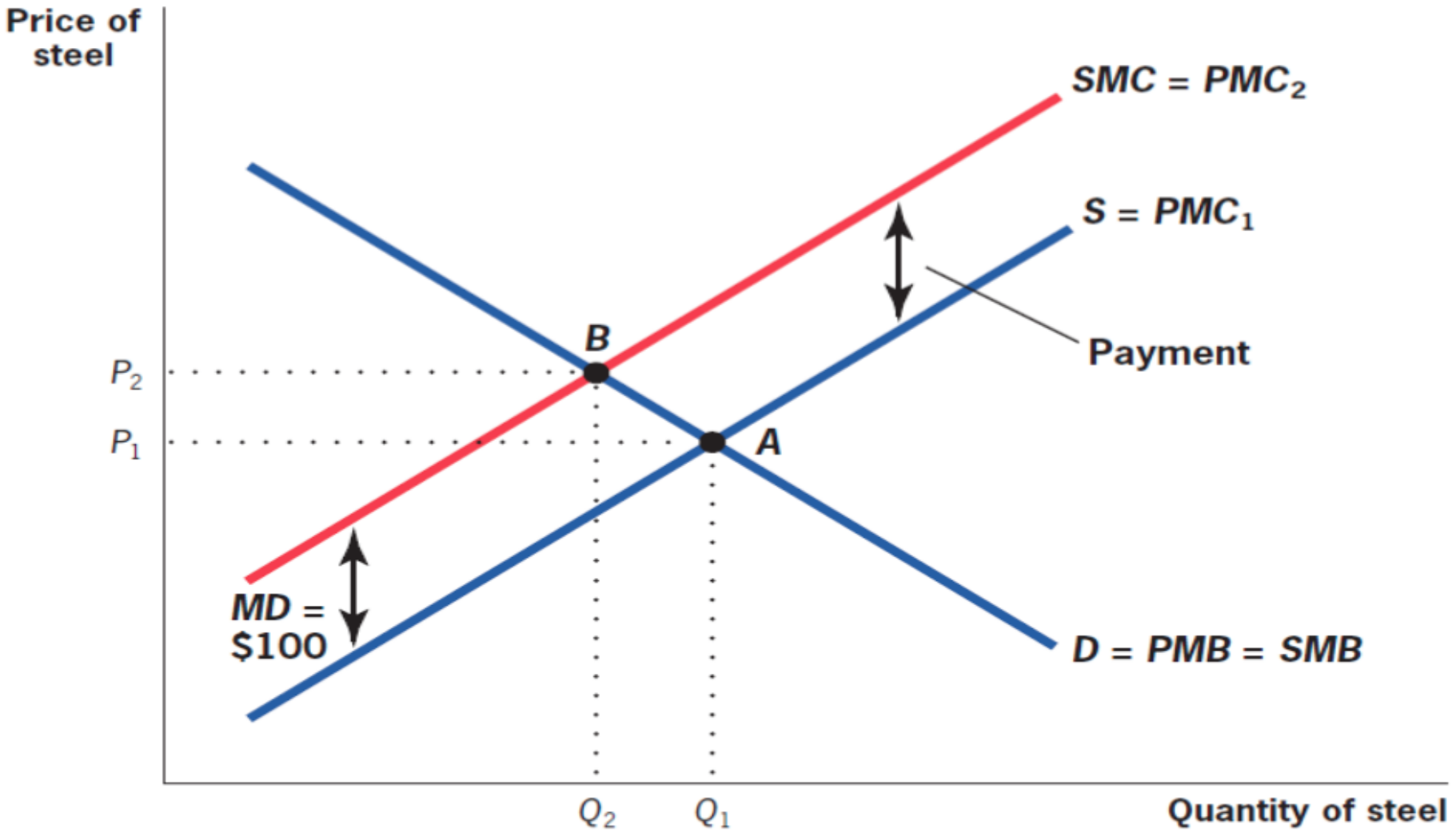
Positive consumption externality – illustration



Private market solutions: the Coase Theorem

- Private market solution to externalities: create a market that assigns a price to the unpriced resource causing the problem
- Original paper: Coase (1960) – examples of neighbors negotiating a resolution to one creating a nuisance for the other
- Usually stated as the two-part Coase "Theorem":
  1. *When there are well-defined property rights and costless bargaining, negotiation between the party creating the externality and the party affected by the externality delivers the socially optimal quantity*
  2. *The private market solution to an externality problem does not depend on which party is assigned property rights, as long as someone is assigned property rights*

Private market solution – Coasian payments



Source: Gruber, *Public Finance and Public Policy*, Figure 5.5

When does the Coase Theorem work?

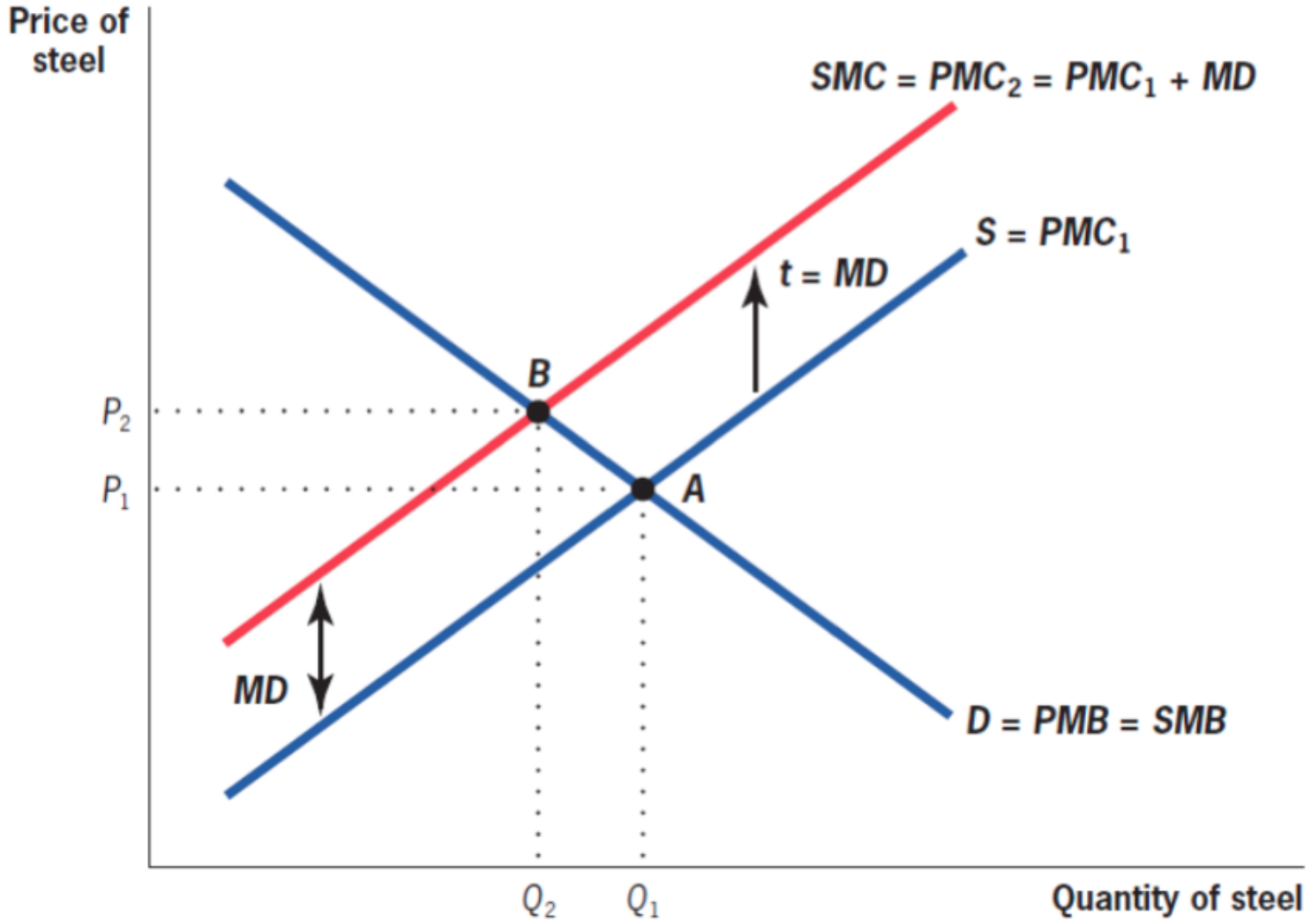
- The Coase Theorem holds when...
  - Transaction costs are low – individuals must be able to trade the previously unpriced resource without barriers
  - Property rights are easily enforced and protected (by government if need be)
  - The market for the originally unpriced resource is competitive (no monopolies or asymmetric information)

- The Coase Theorem fails when...
  - There are coordination problems: external effect applies to many parties at the same time, so difficult to assign blame and property rights
  - Uncertainty in the MD from the good causing the externality (do we really know the MD from one more smoked cigarette?)
  - There are substantial costs to bargaining due to a large number of involved parties

Public solutions to externality problems

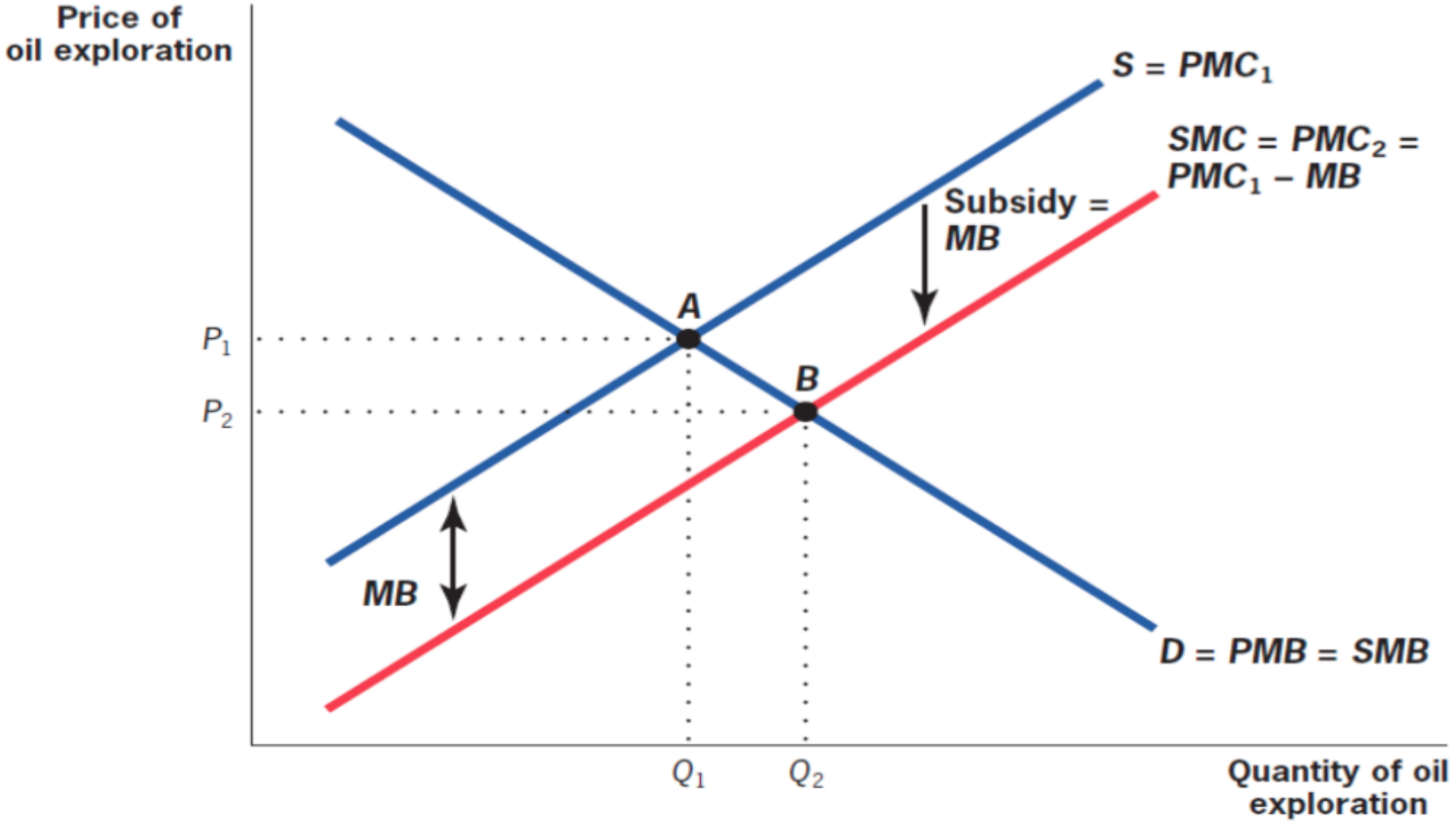
- When the private market solution fails, the government can address the externality problem through two main types of interventions
- Price regulation (taxes/subsidies)
  - Tax goods causing negative externalities and subsidize goods causing positive externalities
  - Pigouvian tax/subsidy: restore efficiency by imposing a per-unit tax equal to the MD
- Quantity regulation
  - Direct regulation: fix the quantity at the efficient level
  - Cap and trade: introduce a fixed quantity of rights to use the unpriced resource and allow parties to trade these rights

Pigouvian tax in action



Source: Gruber, *Public Finance and Public Policy*, Figure 5.6

Pigouvian subsidy in action



Source: Gruber, *Public Finance and Public Policy*, Figure 5.7

Heterogeneous adjustment costs

- Uniform direct regulation will generate allocative inefficiencies if firms have different costs of adjusting production
- Suppose there is a negative externality from pollution caused by production of a good
- Need firm-specific regulation to make sure the marginal cost of abatement (PMC) is equal across firms
  - Otherwise regulation shifts the burden of pollution reduction to firms for which it is particularly costly to adjust
- Since MD may differ by location, government needs to know PMC and PMB by location for direct regulation to be efficient
- Infeasibility of direct regulation a motivation for cap and trade

Sample problem – heterogeneous pollution reduction costs

- 4 firms (A,B,C,D) in an industry with respective total costs of eliminating pollution: $R_A^2, R_B^2/2, R_C^2/3, R_D^2/4$
- Total pollution reduction target: $R^* = R_A + R_B + R_C + R_D$
- First derive the marginal cost of meeting the reduction target R^* that minimizes overall costs
  $\implies$ need $SMC = MC_A = MC_B = MC_C = MC_D$ to hold
- Compute marginal costs for each firm:

$$MC_A = 2R_A \implies R_A = SMC/2$$
$$MC_B = R_B \implies R_B = SMC$$
$$MC_C = 2R_C/3 \implies R_C = 3SMC/2$$
$$MC_D = R_D/2 \implies R_D = 2SMC$$
$$\implies R^* = 5SMC \implies SMC = R^*/5$$

Sample problem continued

- Suppose the government sets a reduction target of $R^* = 120$ and requires each firm to reduce pollution by 30 units
- There will be a DWL from uniform direct regulation because we don't allow firms to trade rights to pollute (i.e. carbon credits)
- We can compute each firm i's contribution to this total DWL

$$DWL_i = \frac{1}{2}|(R_i - R_i^{trade}) \times (SMC - MC_i)|$$

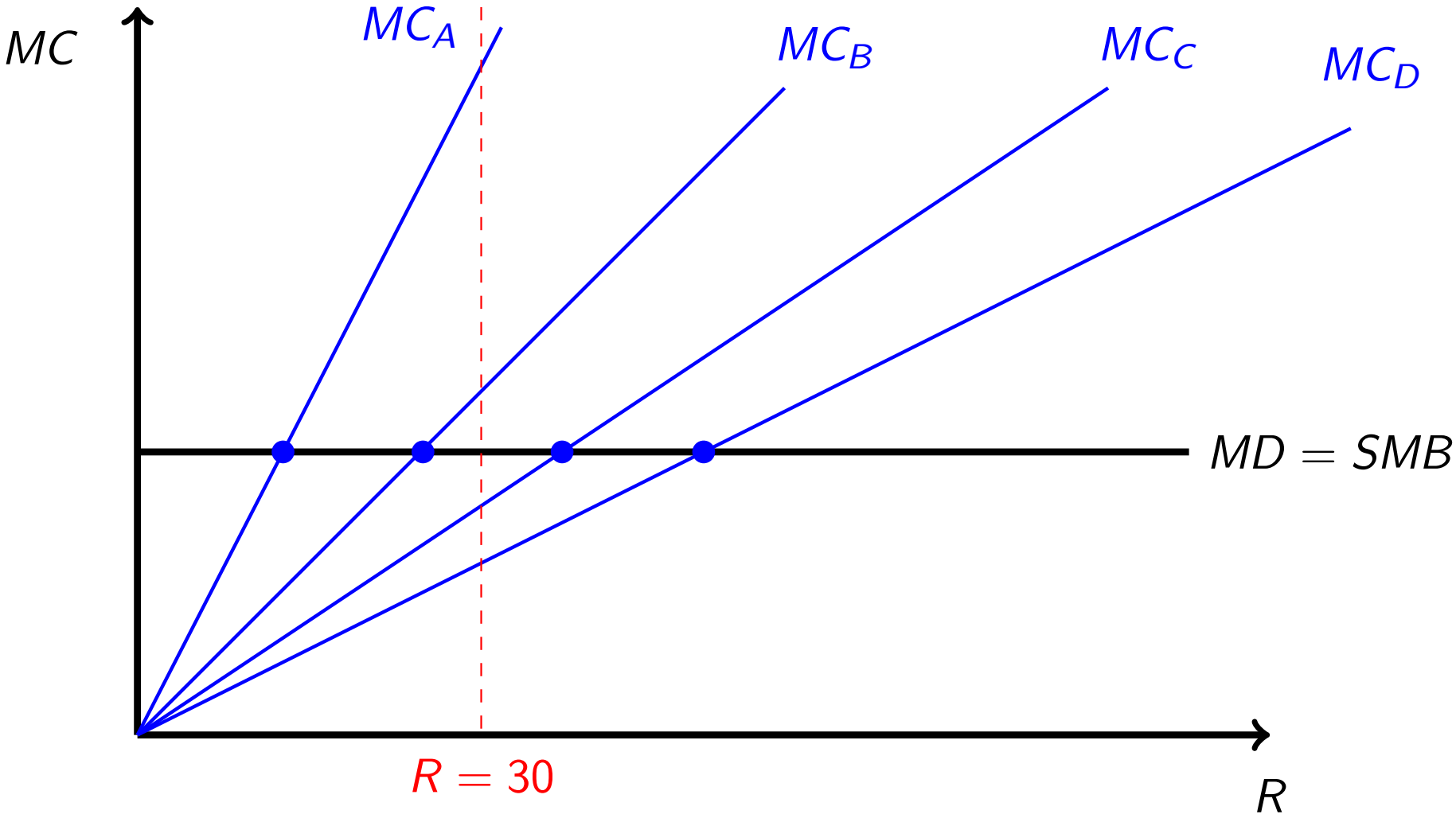
$$DWL_A = \frac{1}{2}|(30 - 12)(24 - 2R_A) = 324$$

$$DWL_B = \frac{1}{2}|(30 - 24)(24 - R_B)| = 18$$

$$DWL_C = \frac{1}{2}|(30 - 36)(24 - 2R_C/3)| = 12$$

$$DWL_D = \frac{1}{2}|(30 - 48)(24 - R_D/2)| = 81$$

Firms with different reduction costs



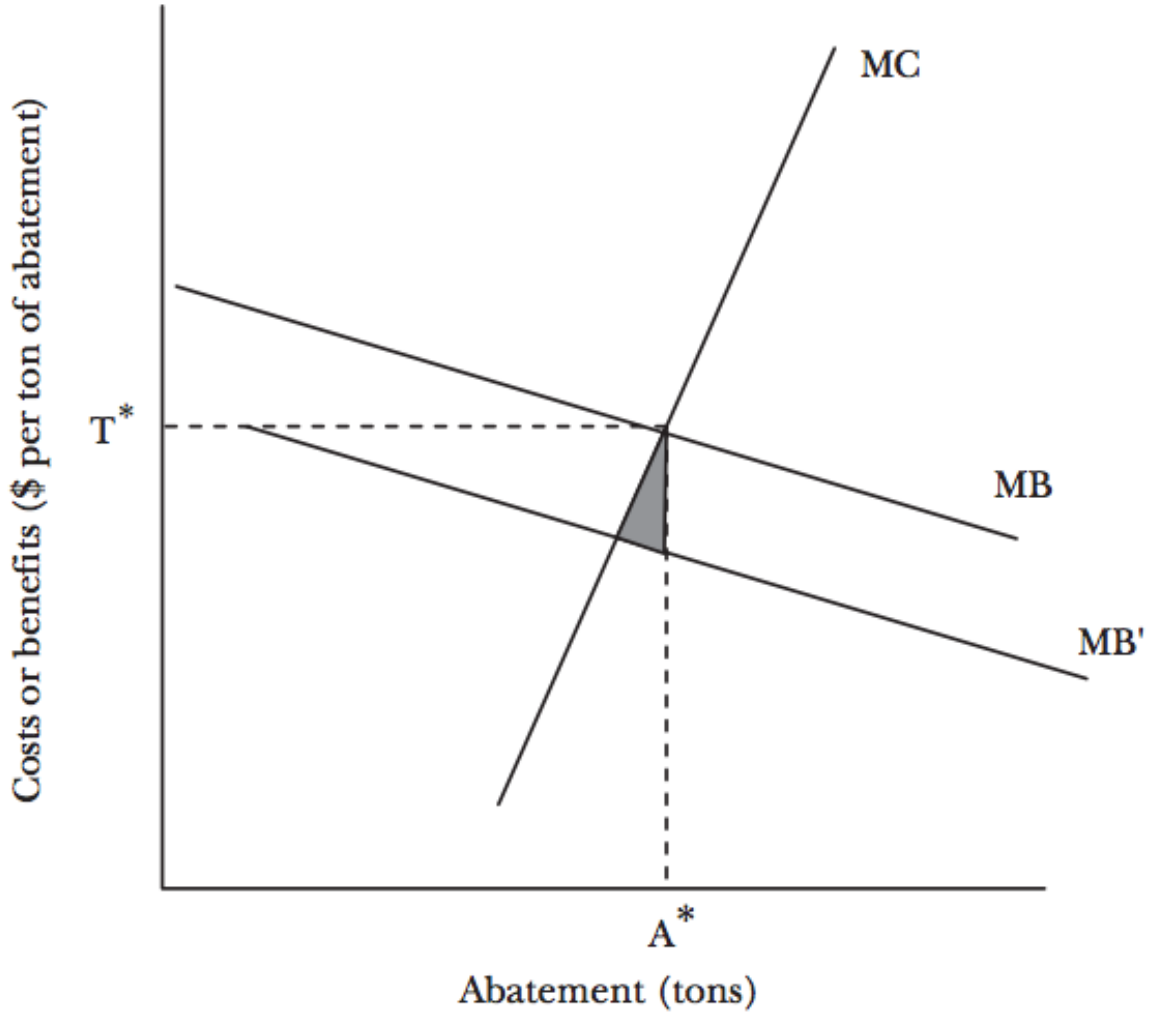
Price vs. quantity regulation (no trade and no uncertainty)

- When there is no uncertainty and firms are identical, Pigouvian taxes and uniform quantity regulation yield the socially optimal quantity
- Under no uncertainty a Pigouvian tax and cap and trade are equivalent
- But uniform direct regulation introduces dynamic inefficiencies
  - Once a firm complies with the regulation, no incentive to invest in innovations that would reduce pollution and lower costs
- No dynamic inefficiency with Pigouvian tax
  - Firms can lower their tax liability by taking steps to reduce their long-run environmental footprint

Price vs. quantity regulation under uncertainty

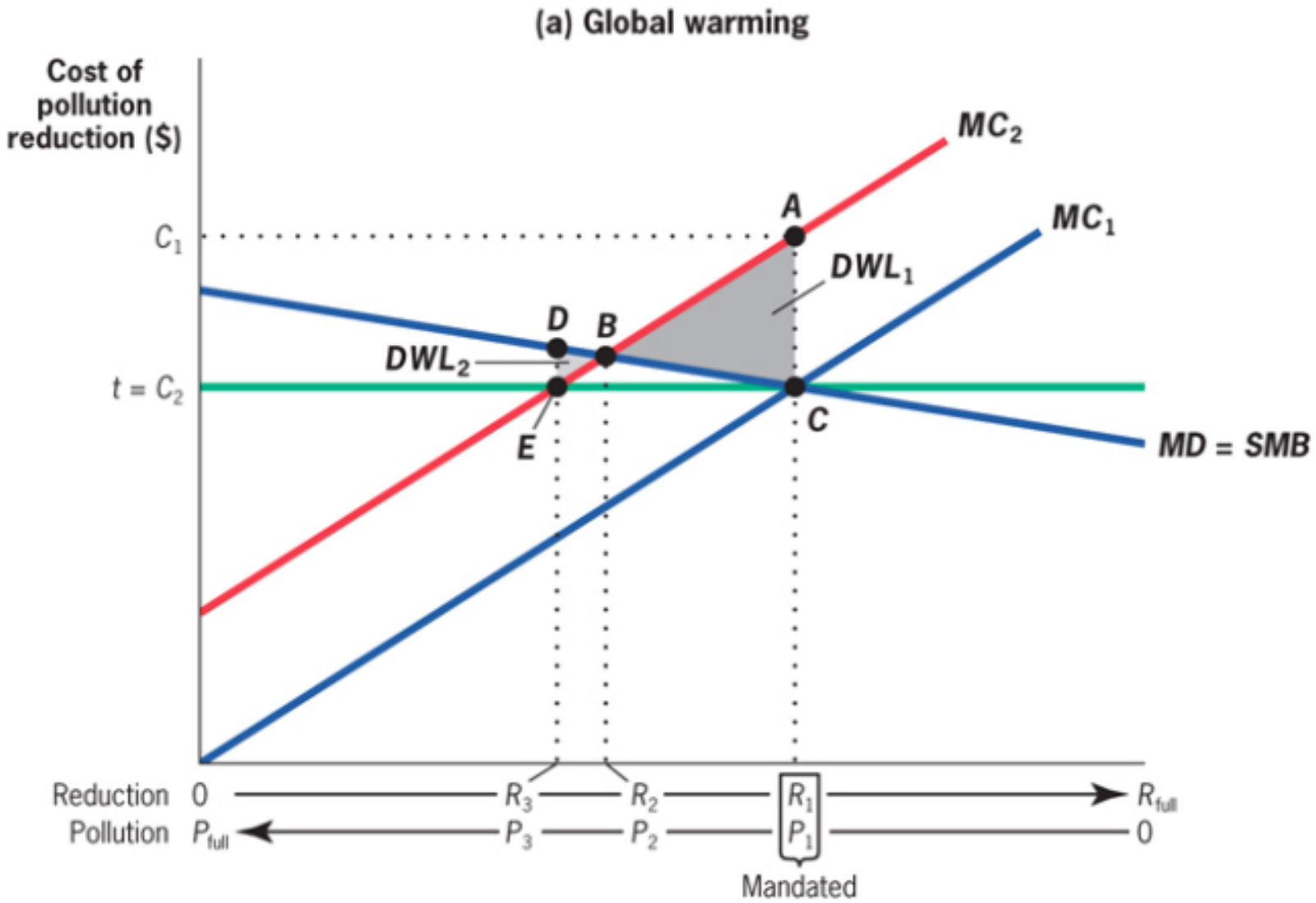
- Government in practice will not know the exact SMB or SMC of reducing the externality
- If uncertain about the SMB, then the DWL from guessing wrong is the same under a tax vs. cap and trade
- If uncertain about the SMC, the DWL from guessing wrong will differ under the two policies
  - If more important to minimize costs (SMB curve is flat), then a tax produces a smaller DWL
  - If more important to get the quantity correct (SMB curve is steep), then cap and trade produces a smaller DWL

Uncertainty about marginal benefits of abatement



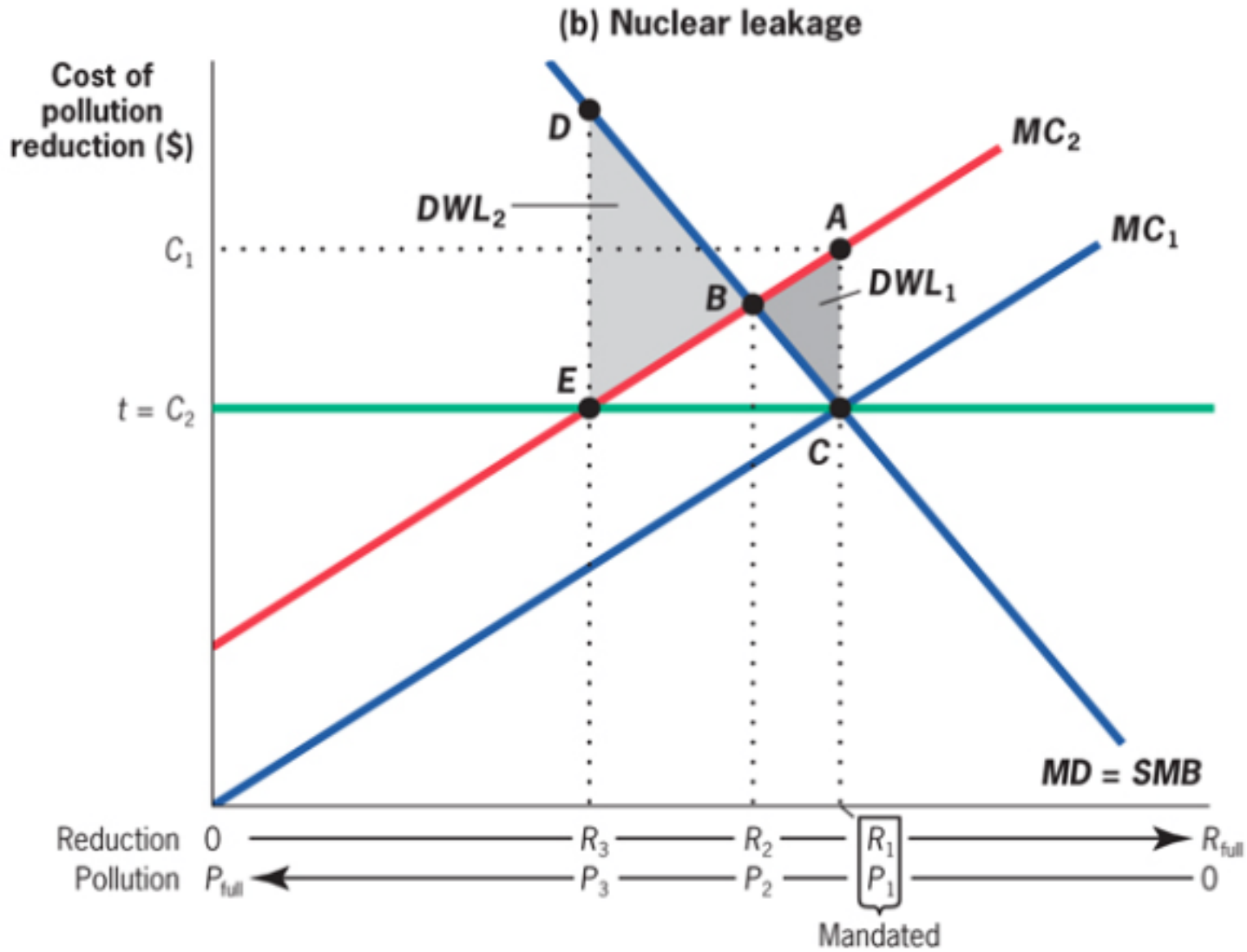
Source: Metcalf (2009), "Market-based Policy Options to Control U.S. Greenhouse Gas Emissions," *Journal of Economic Perspectives*

Uncertainty about MC – tax preferred



Source: Gruber, *Public Finance and Public Policy*, Figure 5.10a

Uncertainty about MC – regulation preferred



Source: Gruber, *Public Finance and Public Policy*, Figure 5.10b

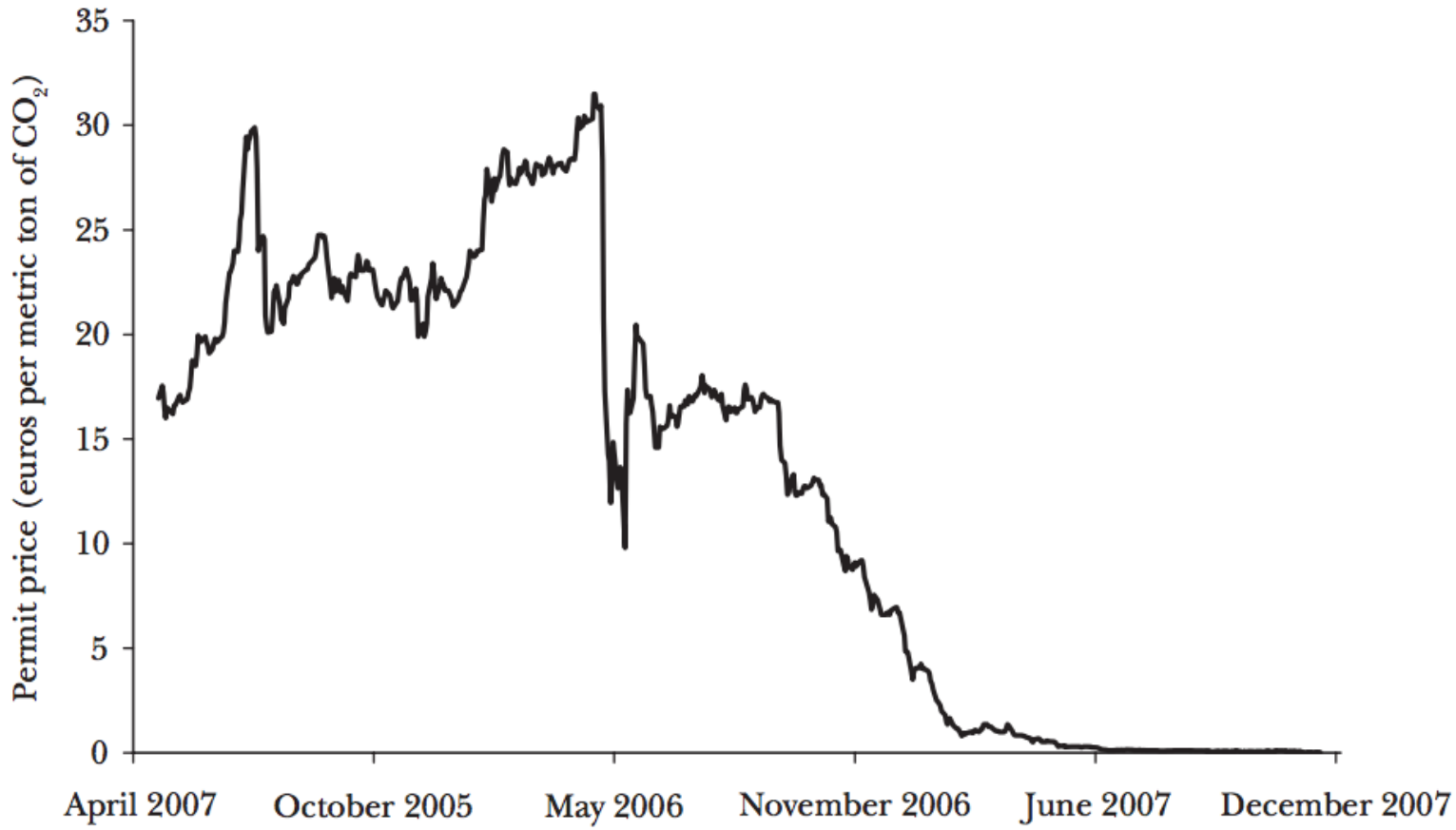
Cap and trade with bankable permits

- Allowing firms to save, or "bank" their carbon permits for later use helps improve efficiency of the system
- Restrictions on emissions are expected to get tighter in the future, making future permits more valuable
- Bankable permits allow firms to make relatively inexpensive reductions now to smooth adjustment costs
- EU Emissions Trading Scheme did not allow unused permits allocated in Phase I (2005-2007) to be carried over to Phase II (2008 - 2012)
- Market price for Phase I permits quickly plummeted to zero as Phase II approached

The importance of making permits bankable

Figure 1

Permit Price for Carbon Emissions, Phase 1 of the European Union's Emissions Trading Scheme



Source: Metcalf (2009), "Market-based Policy Options to Control U.S. Greenhouse Gas Emissions," *Journal of Economic Perspectives*

Empirical applications

- Need data to guide the design of corrective policies for externalities
- Main questions asked in empirical applications:
  - Is there an externality?
  - If so, what are the marginal damages?
  - What are the costs (and the incidence) of regulations?
  - What are the costs of complying with regulations?
- After answering these questions, use theory to choose price vs. quantity regulation and calibrate the corrective tax/subsidy or cap

Is there an externality from air pollution?

What are the effects of air pollution on mortality?

- Why is this a tricky empirical question?
  - Location choice – people may sort into areas based on the pollution level if they value clean air
  - If examine adult mortality, there is selection because focusing on those who survived
  - Current vs. lifetime exposure
- Chay & Greenstone (2003): look at *infant* mortality rates and geographic variation in pollution shocks during the 1981-82 recession
- A $1 \mu g/m^3$ reduction in TSPs associated with ≈ 200 additional infants surviving to be at least one year old
- Large effects even among areas already meeting the EPA air quality standard ($75 \mu g/m^3$)

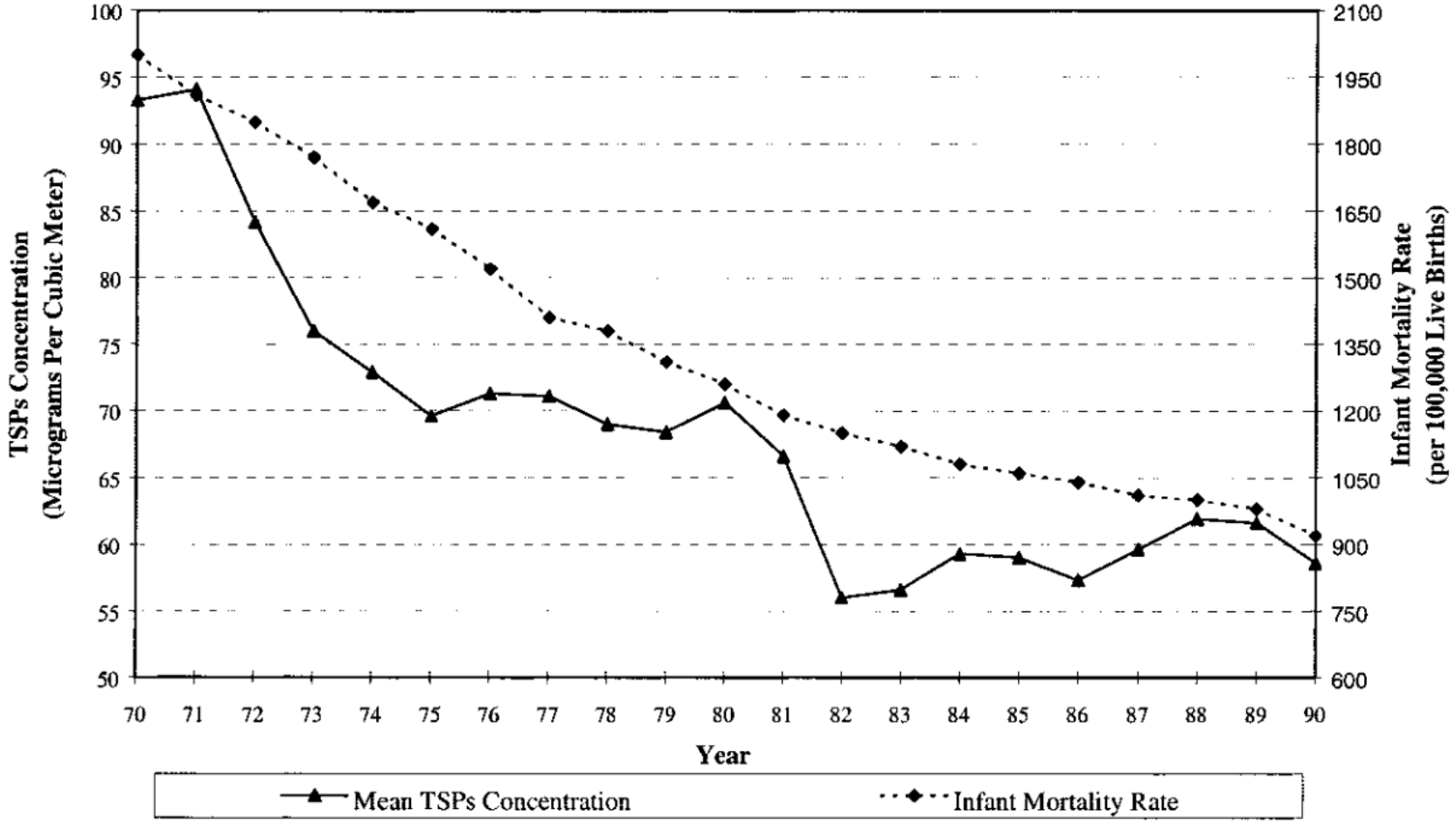
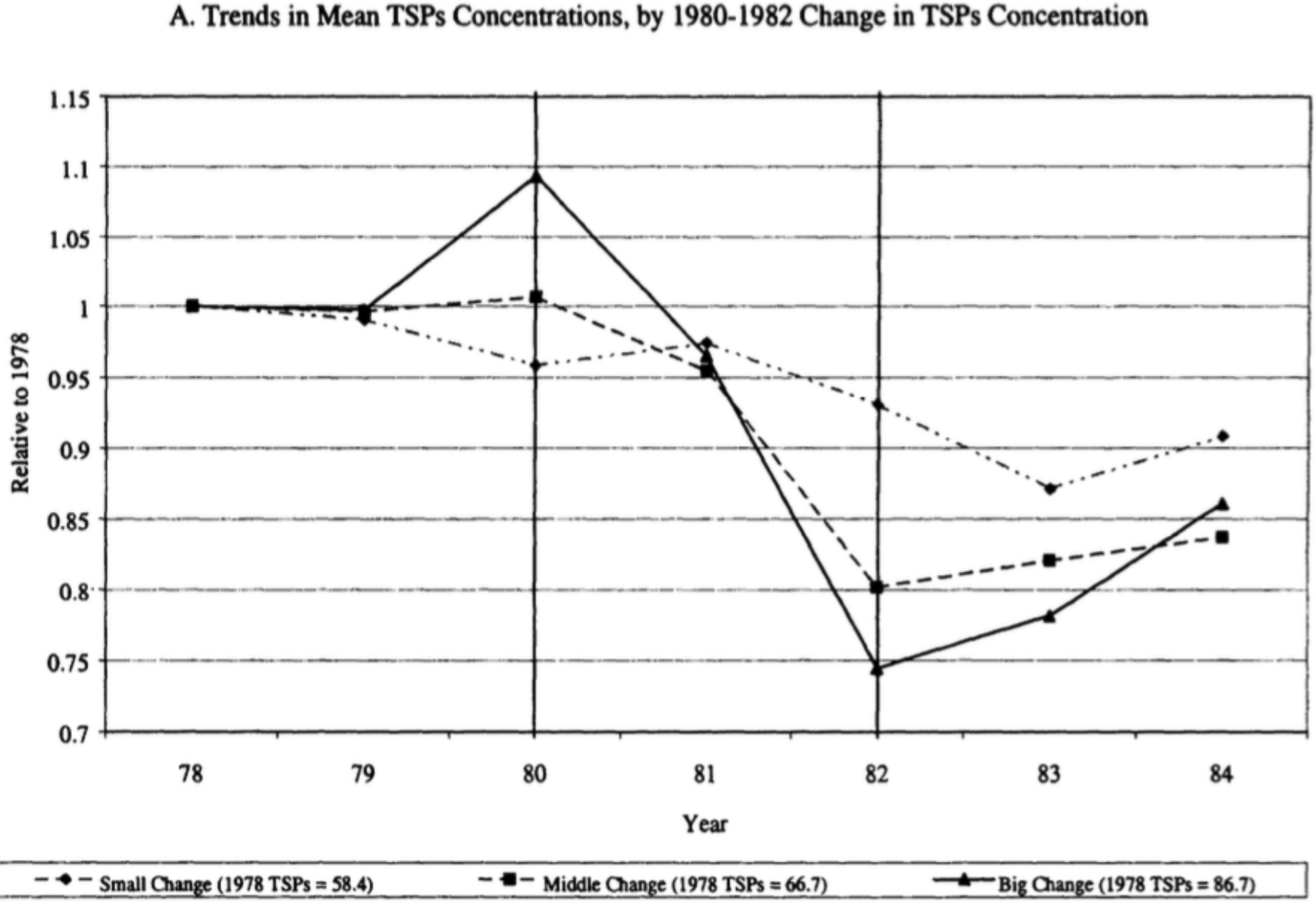


FIGURE I
National Trends in Total Suspended Particulates Air Pollution and Infant Mortality Rates

Source: Chay & Greenstone (2003), "The Impact of Air Pollution on Infant Mortality," *Quarterly Journal of Economics*



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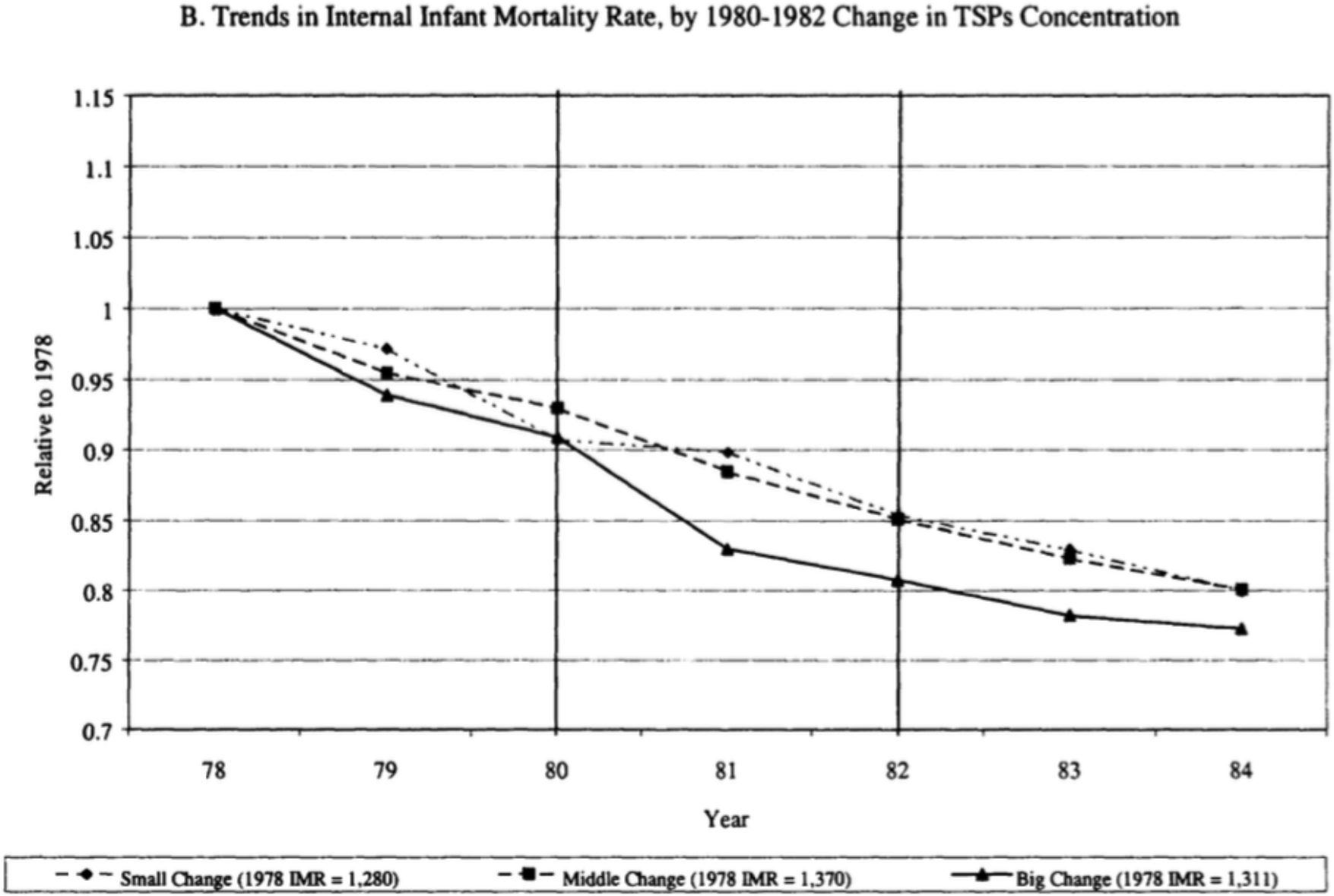
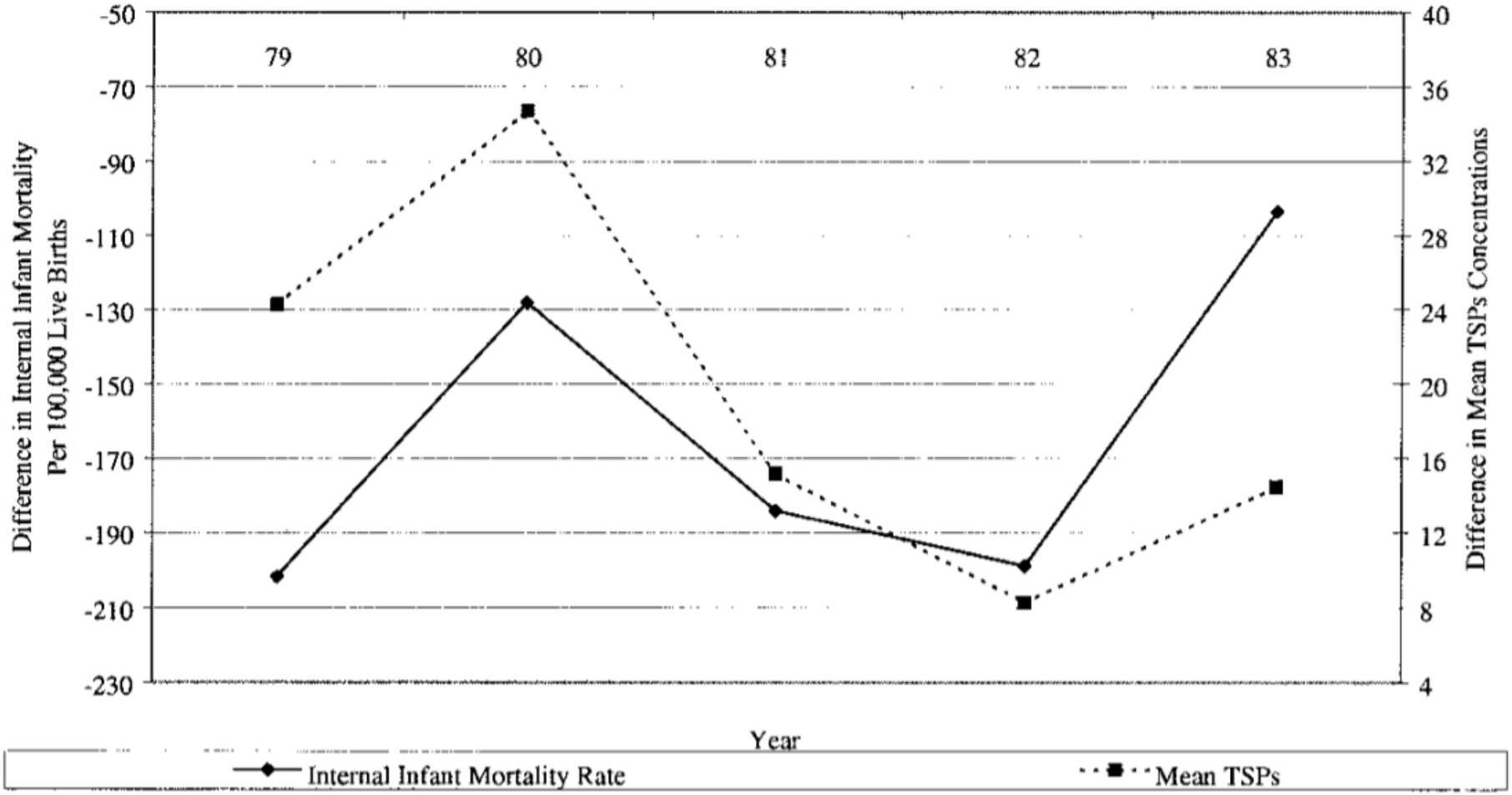


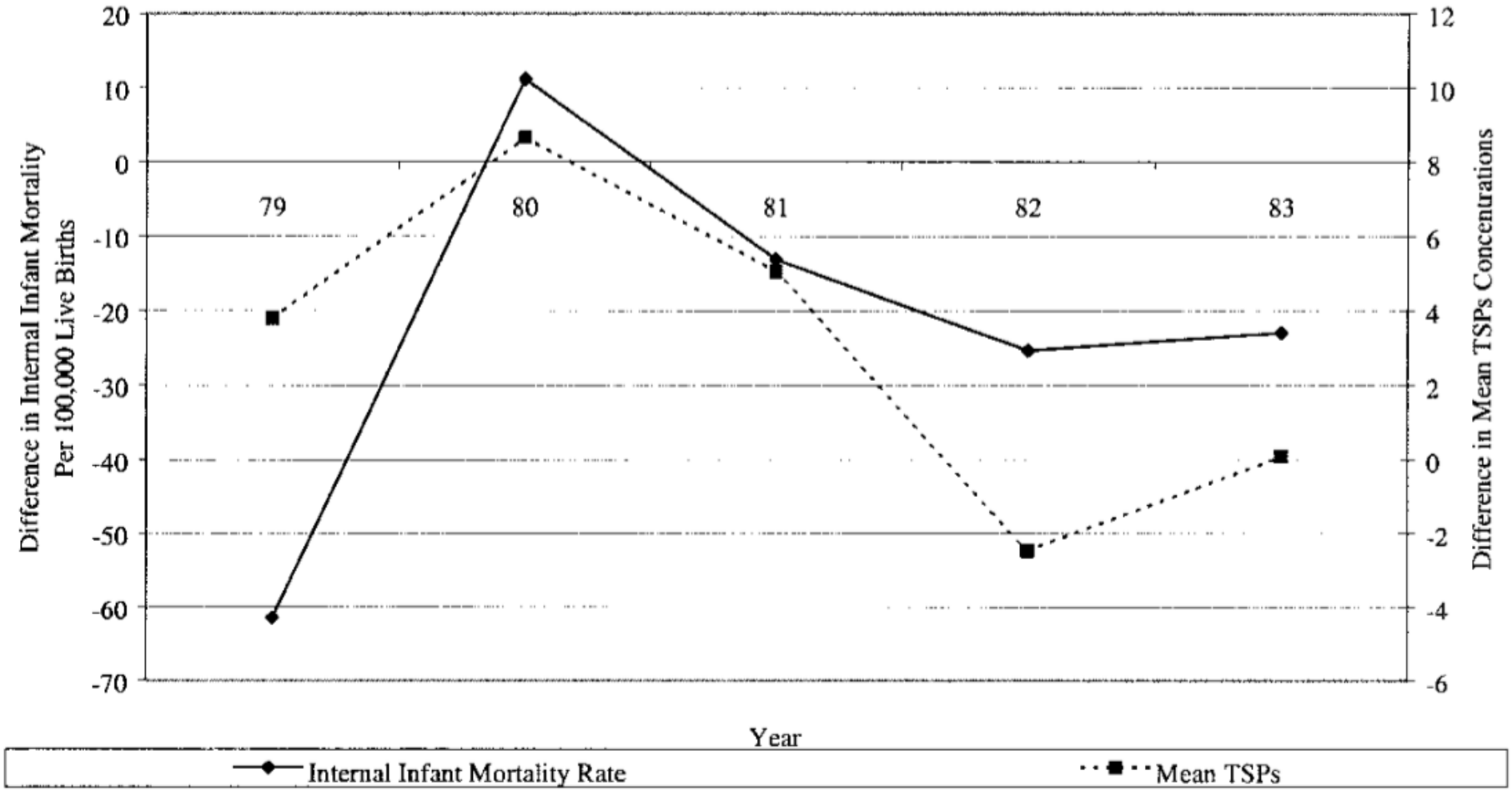
Source: Chay & Greenstone (2003), "The Impact of Air Pollution on Infant Mortality," *Quarterly Journal of Economics*

A. Differences Between the Groups with Big and Small TSPs Changes and Small Income Shocks during 1980-82[1]



Source: Chay & Greenstone (2003), "The Impact of Air Pollution on Infant Mortality," *Quarterly Journal of Economics*

B. Differences Between the Groups with Medium and Small TSPs Changes and Small Income Shocks during 1980-82[1]



Source: Chay & Greenstone (2003), "The Impact of Air Pollution on Infant Mortality," *Quarterly Journal of Economics*

How to estimate marginal damages ($)?

- Market-based measures
  - Use present discounted value of lifetime earnings as value of life
  - Or use changes in the market price of some asset to quantify the MD
- Survey-based measures
  - Ask people how much they are willing to pay to remove an externality
  - Purely hypothetical – are people incentivized to respond honestly?
- Revealed preferences based on individual choices
  - How much do people pay to avoid externalities, or how much are they paid to compensate them for the nuisance?
- Revealed preferences based on government choices
  - Government agencies place a value on a statistical life to do cost-benefit analysis of regulation
  - Examples: FDA uses $7.9 million to value cigarette warning labels, EPA uses $9.1 million to value pollution reduction

Example: market-based approach with auto insurance

- Edlin & Karaca-Mandic (2006): what is the relationship between traffic density and average insurance costs/premia?
  - Externality: if one person starts driving, he/she increases every other driver's accident probability
  - Insurance premium does not depend on individual contribution to insurance costs, but on average cost within a market
  - Only assesses MD from insurance externalities, not other externalities due to having an additional driver on the road
- Find large externalities in traffic-dense states (California)
- Exploit differences in changes in traffic density over time – DD style design comparing high-density to low-density states

Traffic density and auto insurance costs

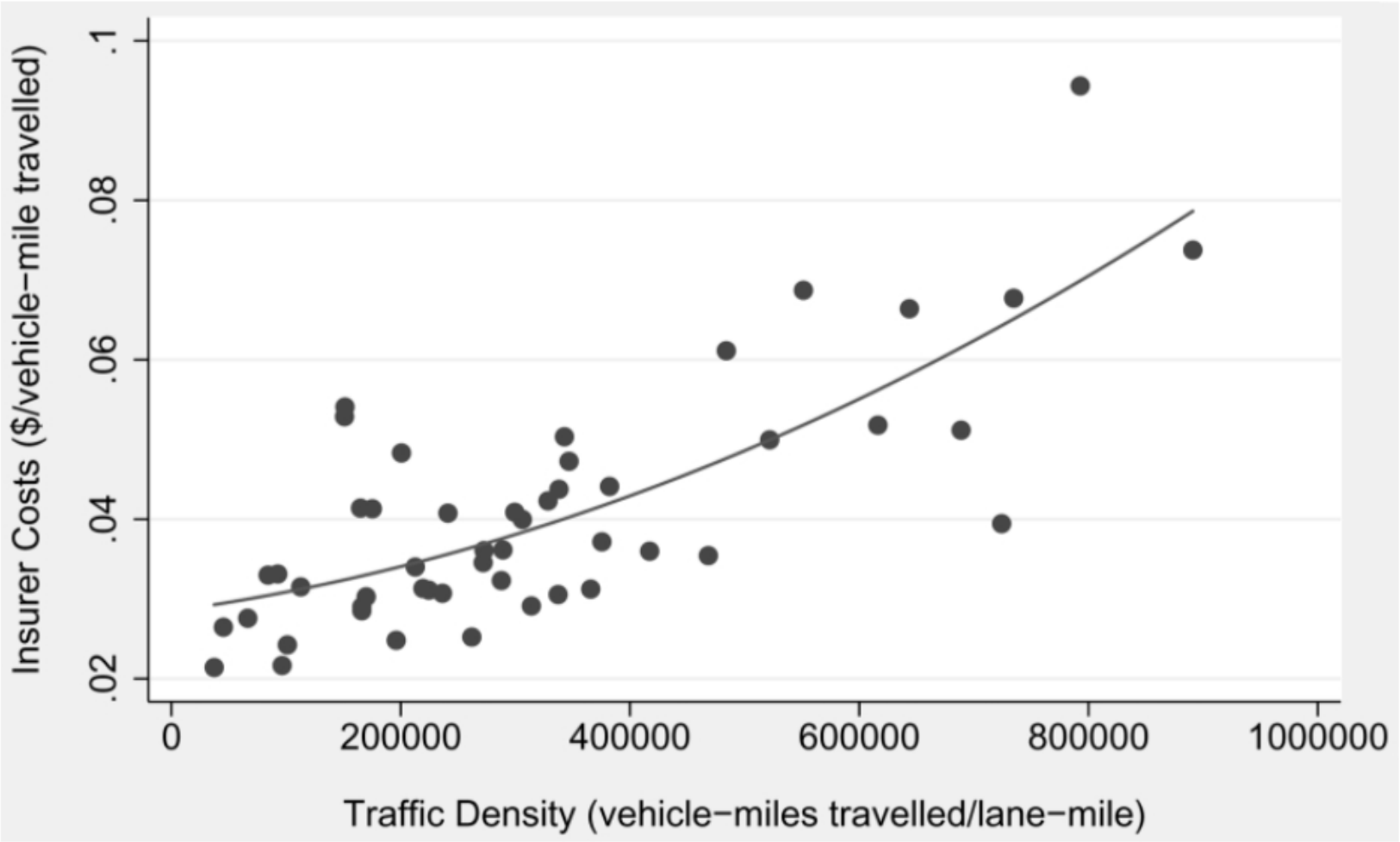


FIG. 1.—Traffic density and insurance costs (1996 dollars)

Source: Edlin & Karaca-Mandic (2006), "The Accident Externality from Driving," *Journal of Political Economy*

Traffic density and auto insurance premia

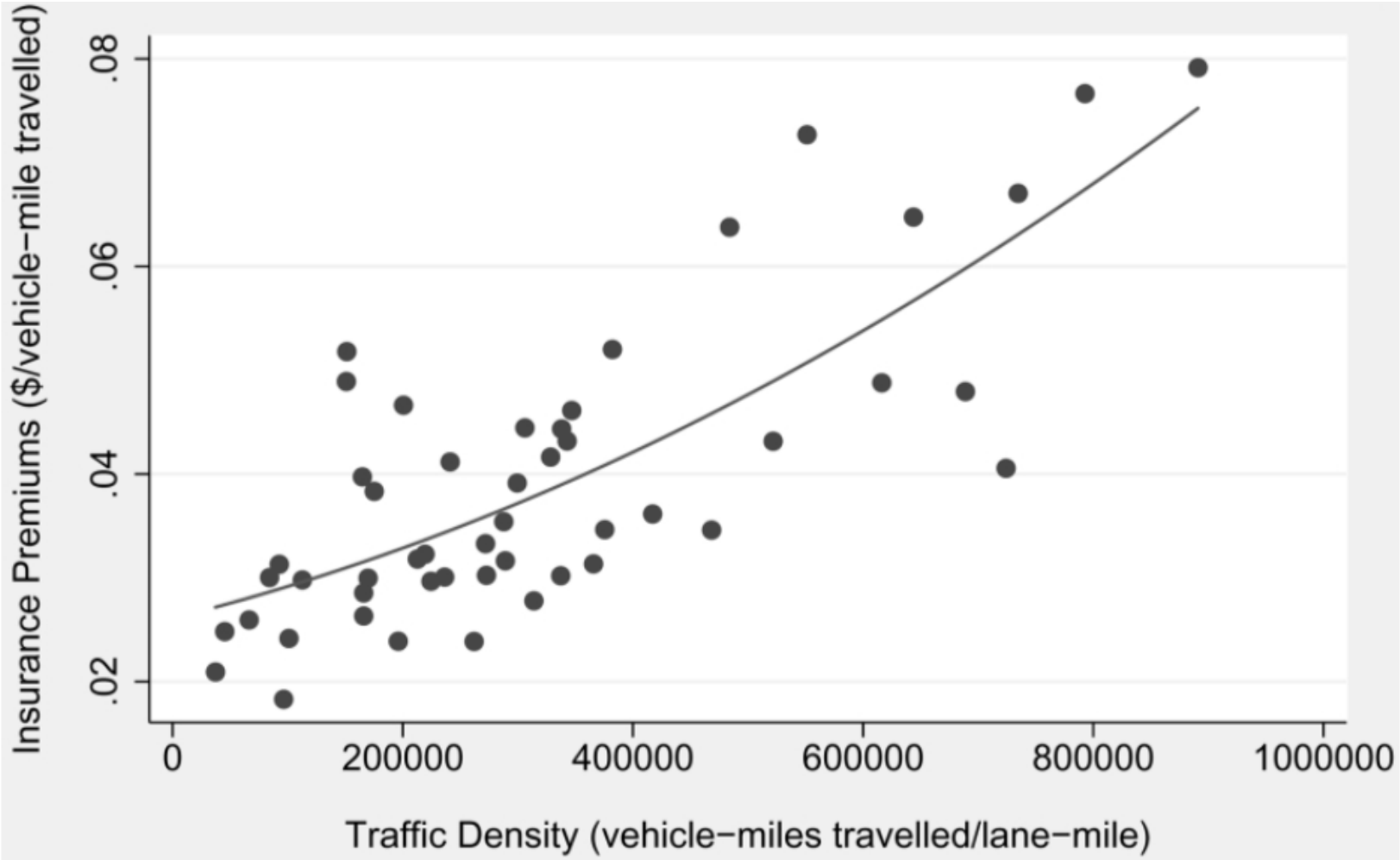


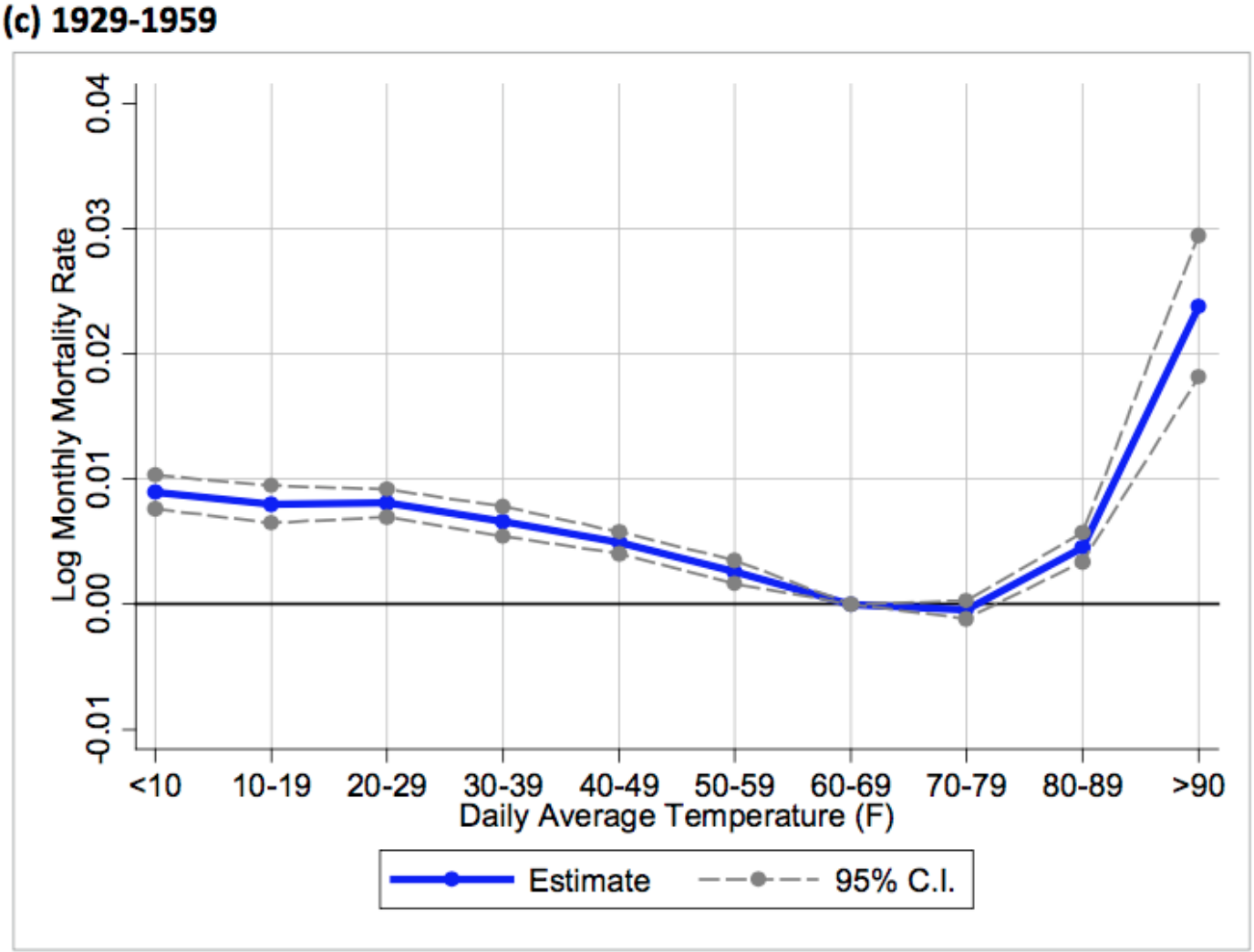
FIG. 2.—Traffic density and insurance premiums (1996 dollars)

Source: Edlin & Karaca-Mandic (2006), "The Accident Externality from Driving," *Journal of Political Economy*

Estimating long-term externalities

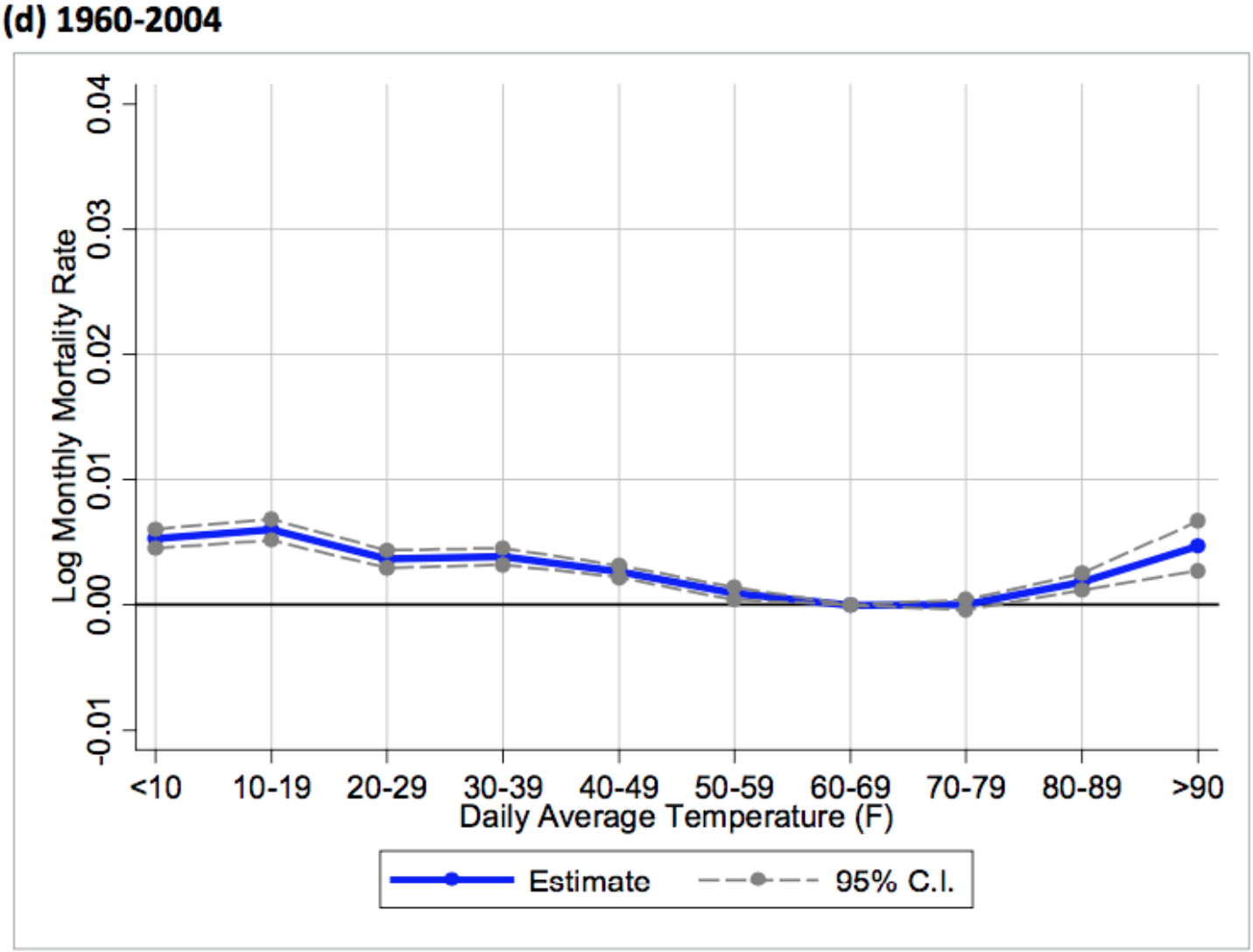
- Some externalities (e.g. climate change) impose costs that are not realized immediately
- Estimating the costs of climate change is daunting because
  - Difficult to forecast all future impacts
  - Society may adapt and reduce costs
  - How do we discount future costs? What is the appropriate discount rate for social vs. private investments?
- Barreca et al. (2016): relationship between heat waves and mortality has vanished over time
  - Mortality effect of an extremely hot day ($> 90°$F) declined by $\approx 80\%$ between pre-1960 and post-1960 periods
  - Adoption of residential AC explains the entire decline

Daily temperatures and mortality rates, pre-1960



Source: Barreca et al. (2016), "Adapting to Climate Change: The Remarkable Decline in the U.S. Temperature-Mortality Relationship over the 20th Century," *Journal of Political Economy*

Daily temperatures and mortality rates, post-1960



Source: Barreca et al. (2016), "Adapting to Climate Change: The Remarkable Decline in the U.S. Temperature-Mortality Relationship over the 20th Century," *Journal of Political Economy*

Internalities

Internalities

- Internalities: costs or benefits accrued to oneself but that are not taken into consideration when making a consumption decision
- Internal costs can be associated with smoking, drinking, poor diet, not saving enough for retirement
- Internalities are a particular kind of self-control problem
  - Example: a smoker would like to quit smoking, makes a plan to do so, but doesn't follow through on the plan
  - Importantly, this is only an internality problem if a plan is made and not followed
- While uninternalized costs and benefits can accrue immediately, most internality problems involve long-term costs (e.g. health problems)

Optimal excise taxes on addictive goods

- Consider an addictive good like cigarettes – what is the optimal excise tax rate on such a good?
- Cigarette consumption imposes externalities – increased health care premia, less-productive workers, secondhand smoke, etc.
- But do cigarettes present an internality problem as well?
  - Internalities are difficult to observe – they often involve long-term costs/benefits and are based on deviations from psychological intent
- If so, a need a "sin tax" to correct the internality problem on top of any Pigouvian tax used to account for the MD from an externality

Rational addiction

- Becker & Murphy (1988): canonical model of addictive goods consumption that features
  - Rational individuals who choose the extent of their addiction
  - Intertemporal choice problem – individuals choose consumption over many time periods
  - Addiction: current consumption increases utility today, decreases future utility, while increasing marginal utility of consumption tomorrow
  - Forward-looking behavior: addicts respond to future anticipated price changes (e.g. changes due to a pre-announced tax increase)
  - If impatient enough (high discount rate), addiction is rational

- In this model no internality to correct: a sin tax would be paternalism

Present-bias

- Gruber & Köszegi (2001, 2004): rational addiction model is empirically indistinguishable from a model with present-bias
  - Individuals overconsume today because they put too little weight on future utility consequences of current behavior (internality)
  - Forward-looking behavior as in the rational addiction model,
  - Consumers respond to price changes but "under-respond"
  - Sin tax on top of any Pigouvian tax needed to correct externalities may help individuals consider the true costs of their current consumption
- Key difference between the two models is the assumptions about how individuals discount future utility from consumption
- See Problem 4 on Problem Set 2

Time-consistent behavior

- Time-consistency: if you were to make a plan at some initial time period, you would follow through with that plan in later periods
- Geometric discounting $\implies$ time-consistency

$$U = u(c_0) + \sum_{t=1}^{T} \beta^t u(c_t)$$

- U is total utility, $u(\cdot)$ is instantaneous utility, and $\beta < 1$
- The individual discounts future utility at a geometric rate: β^t
- The discount rate between any two periods t' and t is always $\beta^{(t'-t)}$
- The rational addiction model features this property

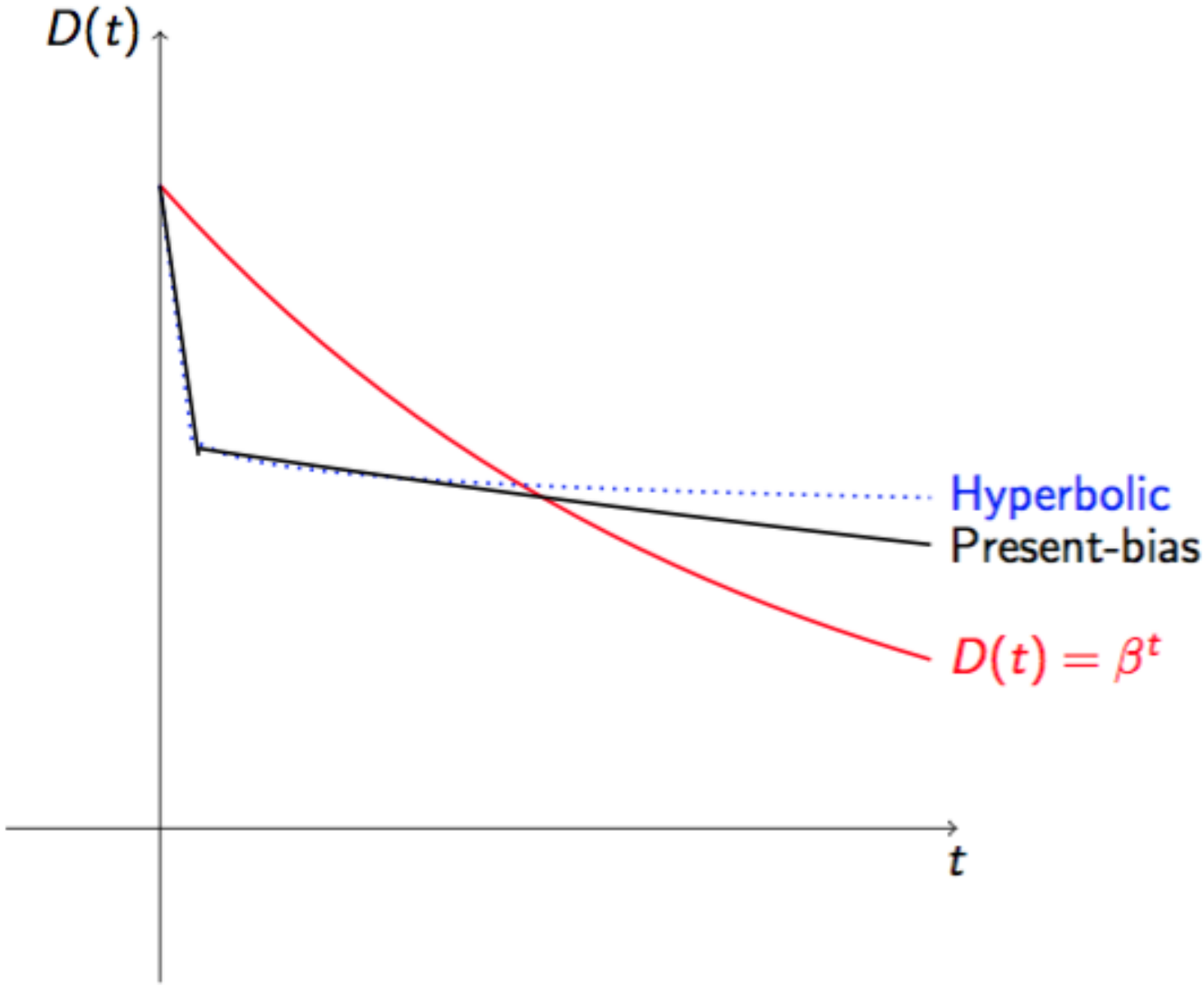
Time-inconsistent behavior

- Time-inconsistency: if you were to make a plan at some initial time period, you would renege on that plan in future periods
- Present-bias (quasi-hyperbolic) discounting $\implies$ time-inconsistency

$$U = u(c_0) + \delta \sum_{t=1}^{T} \beta^t u(c_t)$$

- $0 < \delta < 1$ is the present-bias discount factor
- For any periods beyond tomorrow the individual discounts future utility geometrically
- But when considering the choice between consuming today vs. tomorrow, there is a lower weight on tomorrow's utility
- Time-(in)consistence is a general concept that applies to any decision made over multiple time periods (i.e. not just smoking)

Geometric vs. (quasi) hyperbolic discounting



Empirical evidence of time-inconsistence

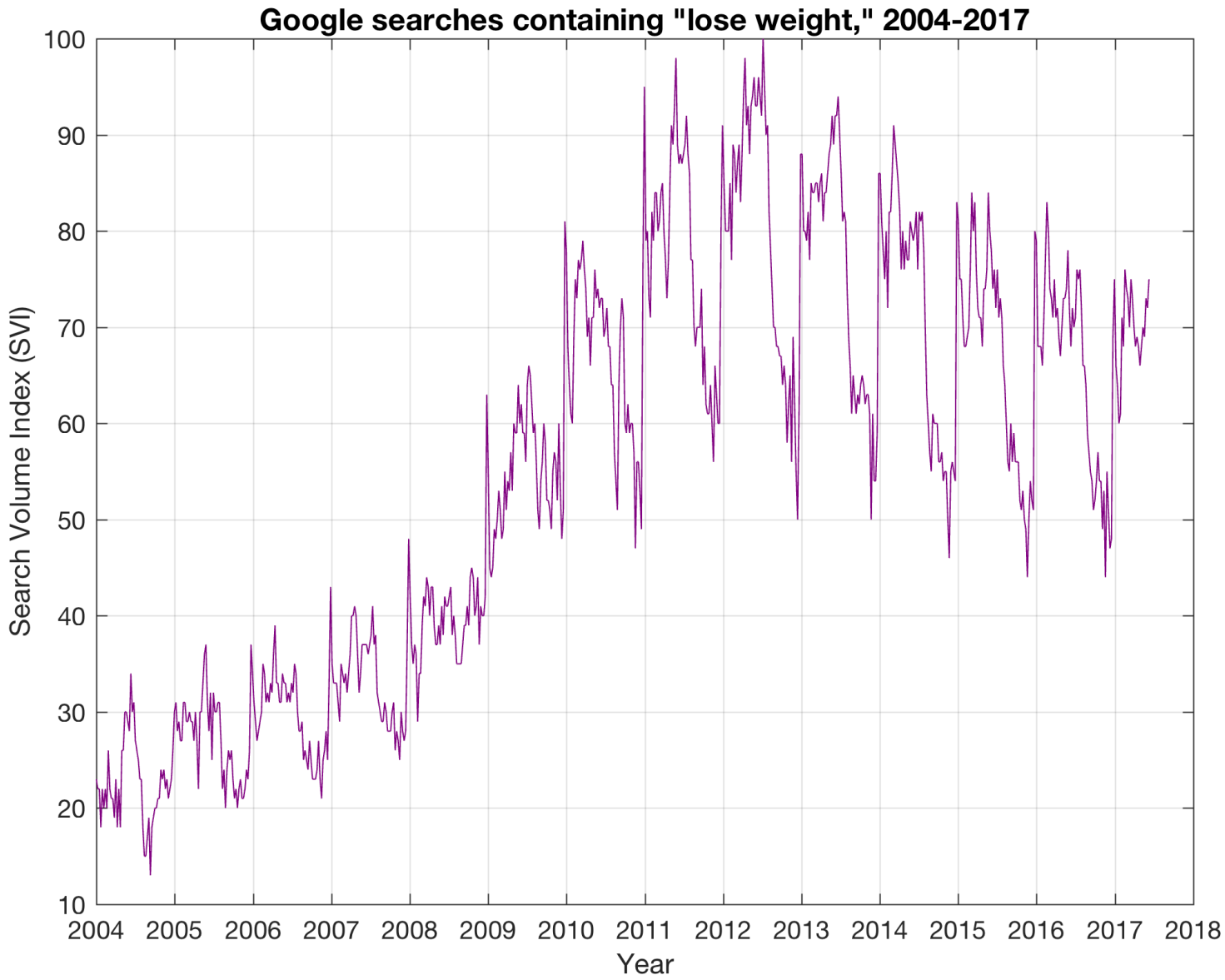
- Many survey experiments have shown that subjects exhibit reversals in choices based on the time horizon (today vs. some future period)
- Basic structure is as in Read & Leeuwen (1998):

(A) Choose between: (A.1) An apple today
(A.2) A chocolate chip cookie today **70%**

(B) Choose between: (B.1) An apple one week from now **74%**
(B.2) A chocolate chip cookie one week from now

- DellaVigna & Malmendier (2006): analyze data on gym membership contracts and find people are overconfident about future self-control
  - Average cost of a gym membership is \$75
  - Average number of visits throughout membership is 4
  - While the pay-per-visit price is \$10

New Year's resolutions



Summary

- Externalities/internalities are market failures that motivate government intervention (failure of the First Welfare Theorem)
- Optimal policy depends on firm heterogeneity, uncertainty about reduction costs, and the flexibility of quantity regulation
- Empirical applications needed to calibrate policy options (e.g. how high should the excise tax rate be?)
  - Distinguishing between real and pecuniary externalities
  - Quantifying MD from externalities – several approaches (market-based vs. revealed preference) each with limitations
  - Providing evidence of internalities that motivate further intervention