Cost-Benefit Analysis of Tobacco Regulations: Principles & Practical Examples

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Outline

- Quick review of basic principles of CBA
- 4 simplified examples of CBAs of tobacco regulations
  - Focus on main concepts: benefits vs. opportunity costs
  - BCA requires evidence-based (not arbitrary) assumptions
  - Simple graphical approach with rigorous foundation
  - Distinguish CBA from stakeholder impact analysis

Principles: CBA and Economic Efficiency of Tobacco Regulations

- CBA is a tool to evaluate whether regulations fix market failures and improves economic efficiency.
  - Economic efficiency requires that societal resources are in their most highly valued use.
- Regulation changes the allocation of resources => winners & losers
- A regulation improves economic efficiency if the winners could potentially compensate the losers, and still be better off themselves.
  - Potential Pareto improvement/ Kaldor-Hicks compensation principle
  - Benefits > Costs ⇔ regulation improves economic efficiency
  - Calculate the sum of the compensating variations in income for everyone who either wins or loses because of the regulation.

Principle: Identifying a policy-significant market failure is the first step in CBA

- First Theorem of Welfare Economics (Invisible Hand Theorem): markets succeed to direct resources to their most highly valued use ⬄ market general equilibrium is economically efficient.
  - Theorem holds depending on a set of assumptions: competitive markets, no externalities, etc.
  - When assumptions don't hold => market failures.
- "If it ain't broke, don't fix it."
  - If market equilibrium is efficient, change cannot improve efficiency.
  - ⬄ change is not a Kaldor-Hicks improvement⬄ change does not yield B > C
- Unhealthy ≠ market failure (necessarily)

Moving from principles to practice: CBA and policy decisions

- The results of CBA *are informative, but are not dispositive*….. (Katzen 2006)
- Most (all?) tobacco regulations will involve winners & losers.
  - B – C > 0 ⇔ winners can potentially compensate loses.
  - But potential compensation payments are not necessarily (usually?) paid.
- Democratically accountable decision-makers make tradeoffs between economic efficiency and other societal goals like equity, justice, …
  - Tradeoffs involve value judgments.
- Value judgments can be embedded into a Social Welfare Function.
  - Example: generalized utilitarian SWF places greater weight on $ gains and losses experienced by disadvantaged groups.
  - SWF => technocrats make the value judgments, instead of democratically accountable decision-makers making valuing judgments.

Practical Examples

- CBA of tobacco regulations is straight-forward in principle, challenging in practice.
- The rest of the presentation discusses the challenges through a set of simplified examples.
- Example #1: CBA of a clean indoor air policy that reduces non-smokers’ exposure to secondhand smoke.
- Example #2: CBA of a cigarette excise tax when consumers are rational and well-informed.
- Example #3: CBA of a cigarette excise tax when some consumers make systematic mistakes and impose internalities on themselves.
- Example #4: CBA of a nudge regulation that changes tobacco product attributes, when some consumers impose internalities on themselves

Example #1: CBA of regulation that bans smoking in public indoor spaces

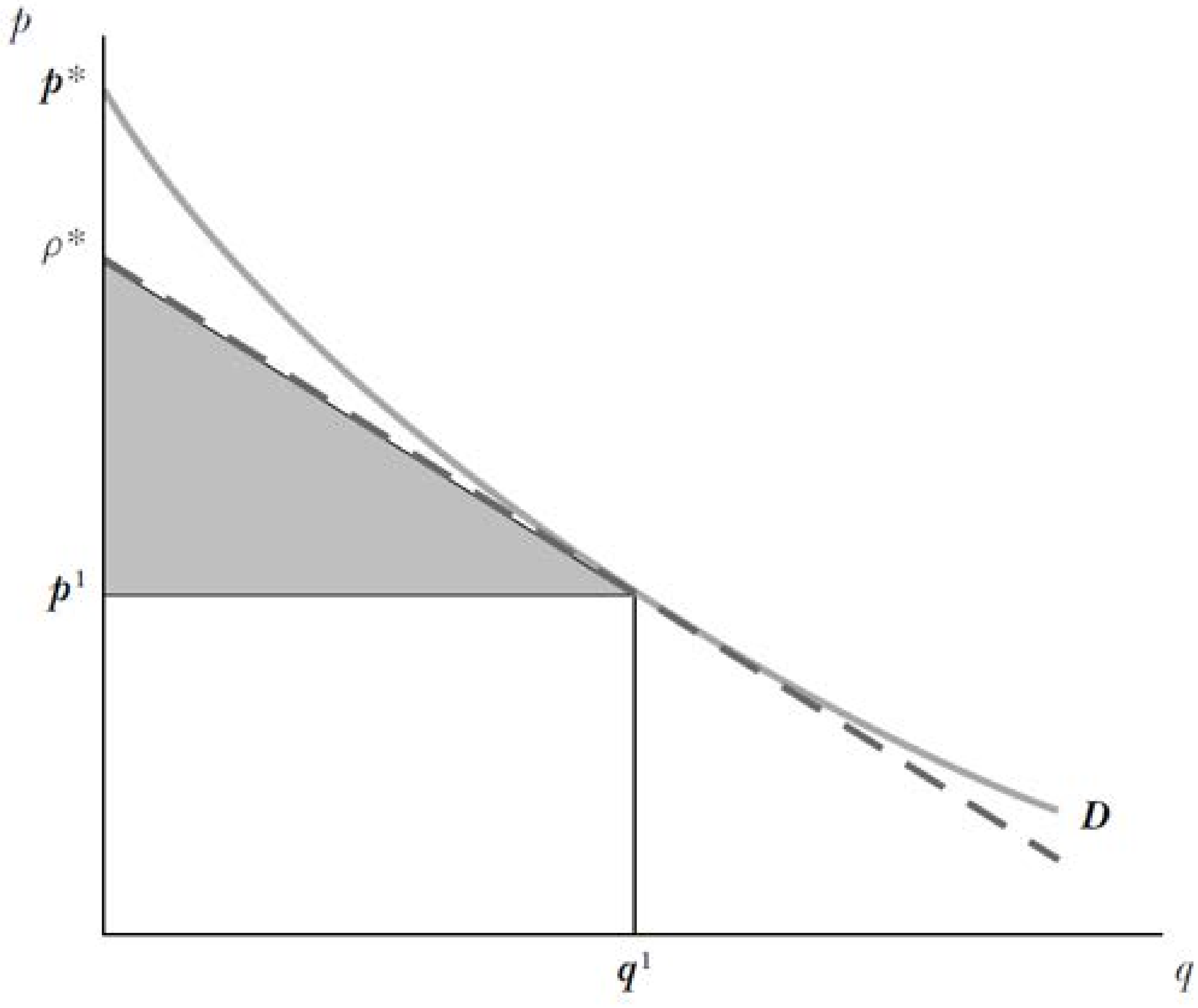
- Market failure: smoking in public indoor spaces imposes a negative externality on non-smokers exposed to secondhand smoke (SHS).
  - FDA (2022) uses an estimate of 41K SHS deaths of U.S. non-smokers annually.
- CBA compares the benefits to non-smokers of reduced SHS exposure to the opportunity costs the ban imposes on smokers.
- Benefits = value of reduction in mortality risks
  - Value of a statistical life summarizes willingness to pay for ↓mortality risks.
  - Risk reduction is probably on the order of magnitude of about 1 in 10,000
  - FDA (2022) uses value of statistical life = $11.8 million

  ⇔ willingness to pay for 1 in 10,000 risk reduction = $1,180 per exposed person

CBA of regulation that bans smoking in public indoor spaces continued

- To find opportunity costs imposed on smokers:
  - Estimate demand curve for smoking in public indoor spaces.
  - Find virtual price p* where the quantity demanded will equal zero.
  - Hausman (2003) suggests that triangular area of consumer surplus gained from a new product/ lost from a banned product is a simple approximation of the value of the product = CV in income for the ban.
- If there are good substitutes for smoking in public indoor spaces, the demand curve will tend to be flat => lower p* required to drive quantity demanded to zero => CV for ban not very large.
  - Possible substitutes include quitting, cutting down, smoking outside, vaping.
  - Unintended consequence: smoking at home (Adda & Cornaglia 2010).
  - Bans often lead to illegal markets; but indoor smoking bans self-enforcing.

New Product



Completing the CBA of bans on smoking in public indoor spaces

- Quasi-experimental estimates of the impact of bans on SHS exposure = ?
  - Adda & Cornaglia (2010) estimate that bans ↑ SHS exposure of nonsmokers
- Retrospective analysis of past reduction in SHS exposure
  - Tsai et al. (2018) estimate that SHS exposure among non-smokers fell from 87.5% to 25.2% from 1988 to 2014.
  - Current annual deaths of 41K due to high exposures in late 1900s
  - Reduced exposure 1988 -2014 => reductions in future SHS deaths.
- If reduced exposure ↓deaths by 30K @ VSL = $11.8 million => benefits = $354 bill./year
- Quasi-experimental estimates of the opportunity costs of the bans = ?
- Break-even calculations => B > C unless opp. costs are over $10K per smoker per year/ $25 per smoker per day.

Example #2: Excise Tax on Cigarettes

- Market failure: none by assumption (to be relaxed later).
  - Goal of the tax is to generate tax revenues for public sector.
- CBA of an excise tax is an analysis of the efficiency cost of taxation.
  - Because there is no market failure, the tax can NOT yield net benefits > 0.
  - Opportunity costs = dollar value (CV) of the utility losses created by the tax.
  - Benefits = Revenues (transferred to other consumers or invested in public goods)
  - Net benefits < 0 => efficiency cost of taxation = deadweight loss of taxation = excess burden of taxation.
- (CBA of how the revenues are used is another question.
  - Example: CBA of an excise tax increase combined with a new government program funded by the tax revenues.)

Sufficient Statistics for Welfare Analysis: A Bridge Between Structural and Reduced-Form Methods (Chetty 2011)

- Static general equilibrium model where consumer is endowed with Z units of numeraire good y and consumes $x_1 \dots x_J$ other goods; each x_j is produced according to cost function = $c(x_i)$. (Chetty 2011, Annual Review of Econ)

To simplify the exposition, we ignore income effects by assuming that utility is quasi-linear in y. The consumer takes the price vector as given and solves

$$\max_{x,y} u(x_1, \dots, x_J) + y \quad \text{s.t. } p \cdot x + tx_1 + y = Z, \tag{1}$$

where $u(x)$ is strictly quasiconcave. The representative firm takes prices as given and solves

$$\max_{x} p \cdot x - c(x). \tag{2}$$

Social Welfare = W (t) = Consumer Surplus + Producer Surplus + Tax Revenues

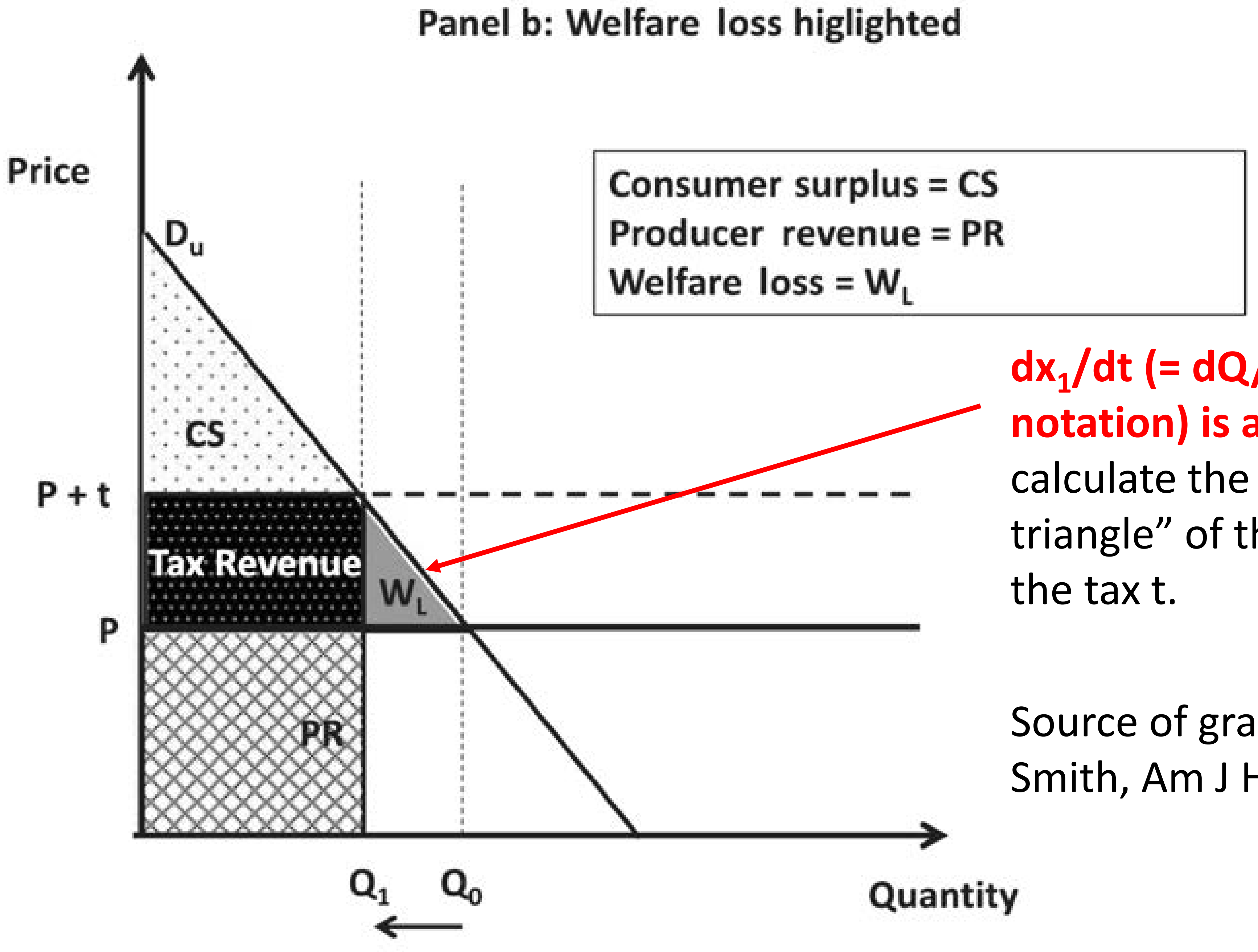
$$
\begin{aligned}
W(t) &= \{\max_x u(x) + Z - tx_1 - p(t)\cdot x\} + \{\max_x p(t)\cdot x - c(x)\} + tx_1 \\
&= \{\max_x u(x) + Z - tx_1 - c(x)\} + tx_1,
\end{aligned}
$$

When calculating dW/dt, the behavioral responses dx/dt in { } can be ignored because of envelope conditions from consumer and firm optimization (substitute in FOCs).

$$
\frac{dW(t)}{dt} = -x_1 + x_1 + t\frac{dx_1}{dt} = t\frac{dx_1(t)}{dt}.
$$

Sufficient Statistic

$$
\Delta W = W(t_2) - W(t_1) = \int_{t_1}^{t_2} t\frac{dx_1}{dt}(t)dt.
$$



dx_1/dt (= dQ/dt in graph's notation) is a sufficient statistic to calculate the size of the "Harberger triangle" of the deadweight loss of the tax t.

Source of graph: Levy, Norton, & Smith, Am J Health Econ 2018

CBA of a Cigarette Excise Tax

- Costs = rectangle + DWL triangle
  - Change in consumer surplus “under” the D curve = CV for the price change
- Benefits = rectangle of tax revenues
- Net Costs = DWL triangle
- Partial equilibrium analysis of the cigarette tax, but use total derivative dx_1/dt

The total derivative $\frac{dx_1}{dt} = \frac{\partial x_1}{\partial p_1}\frac{\partial p_1}{\partial t} + \frac{\partial x_1}{\partial p_2}\frac{\partial p_2}{\partial t} + \ldots + \frac{\partial x_1}{\partial p_J}\frac{\partial p_J}{\partial t}$ measures the effect of an increase in the tax rate on x_1, allowing all prices and equilibrium demands to change endogenously. The simplicity of Harberger’s approach stems from estimating $\frac{dx_1}{dt}$ directly rather than estimating its various components, which is effectively what the structural approach requires.

Envelope theorem and pre-existing distortions

- Envelope theorem means that we don't have to worry about general equilibrium effects in the markets for the non-taxed goods x_2, … x_J – they "envelope out."
  - These effects do not have first-order effects on private welfare.
  - Example: As tobacco farming sector contracts, resources of production flow to their next best alternative use, with no first-order welfare loss.
  - Example: Cigarette industry resources flow to next best alternative use.
  - Example: Non-combustible tobacco production increases.
  - Example: medical resources flow to next best alternative use.
- Envelope theorem expression for dW/dt assumes that there are no pre-existing distortions in the markets for the non-taxed goods x_2, … x_J
  - Possible distortions include taxes on other goods, externalities in other markets, internalities, etc.

CBA is NOT the same as stakeholder impact analysis

- Cigarette excise tax has multiple impacts
  - Consumer welfare
  - Tax revenues

  CBA

  - Rate of smoking among youth and adults
  - Rate of quitting
  - Rates of smoking-related illness and death

  Public health impacts

  - Medical expenditures on smoking-related illness and death
  - Tobacco farming, cigarette & e-cigarette manufacturing, etc.

  Other sector impacts

To repeat: predicting stakeholder impacts is not the same as estimating benefits and costs

- **Stakeholder impact analysis**: Predict impacts on major stakeholders including smokers, non-smokers exposed to SHS, tobacco manufacturers & growers, healthcare system, tax revenues.
- **Public health impact analysis**: Predict impacts on smokers' and non-smokers mortality and morbidity risks.
    - Example: dynamic population health simulation model (Mendez & Warner)
- **Cost-benefit analysis: identifies if resources are in their most highly valued use**
- CBA ≠ maximizing tobacco manufacturers' & growers' revenues or profits
- CBA ≠ maximizing government revenue
- CBA ≠ maximizing public health

Example 3: CBA of an excise tax when some consumers make mistakes and impose on internalities on themselves

- Decision-making errors (individual failures to optimize) => internalities
  - Errors could be due to lack of information or decision-making “errors” explored in behavioral economics research
  - Addiction isn’t necessarily irrational, but addiction => past decision-making errors can continue to affect addictive consumption choices through the consumption capital stock (adjacent complementarity)
- One approach is to distinguish decision utility (which reflects biases) from experienced utility (unbiased, “true” preferences).
  - Consumption choices that maximize decision utility fail to maximize experienced utility.
  - Consumers choose “too much” of goods that impose internalities.

Many arguments for tobacco control polcies rely on the existence of internalities

- Whether tobacco control regulation increases or decreases economic efficiency depends on the existence of internalities.
  - A regulation that restricts rational choices creates opportunity costs for consumers and creates economic efficiency losses.
  - A regulation that restricts choices due to behavioral biases reduces the internalities individuals impose on themselves and create economic efficiency gains.
  - In short, internalities turn an opportunity cost into a benefit.
- Whether tobacco control regulation places a disproportionate burden on poor consumers depends on the existence of internalities.
  - Taxes “help” poorer consumers only when their choices to consume tobacco are mistakes.

CBA should require strong evidence of internalities

- First step of CBA always requires strong evidence of a market failure.
- Bernheim & Rangel (2005): *[S]tandard welfare analysis is grounded in the doctrine of revealed preference. That is, we infer what people want from what they choose…. if we are to relax the principle of revealed preference when evaluating public policy, it behooves us to set a* ***high scientific threshold*** *for reaching a determination, based on objective evidence, that a given problem calls for divergent positive and normative models.*
- Boardman et al. (2022 pp. 1171-1172) propose that the ***rebuttable principle of individual rationality*** should be applied to the possibility that behavioral biases lead to consumer mistakes: *analysts need to present strong empirical evidence that individuals are indeed making serious mistakes….Wherever possible, analysts should look for evidence of the anomalous behavior in markets as well as laboratory experiments.*

Measuring internalities

- Welfare relevant experienced utility from discrete purchase of a good = v
- Decision utility d is biased: d = v + b.
  - Consumers over-estimate utility/ willingness to pay by b because they neglect some or all of the future costs.
- Empirical approach estimates:
  - Market demand from actual purchases based on d.
  - Marginal utility = unbiased demand based on v.
  - Slope of marginal utility curve = ε
- Studies that use this approach include Levy, Norton & Smith (AJHE 2017), Allcott, Lockwood & Taubinsky (QJE 2019, JEP 2019), Allcott et al. (AER 2025).

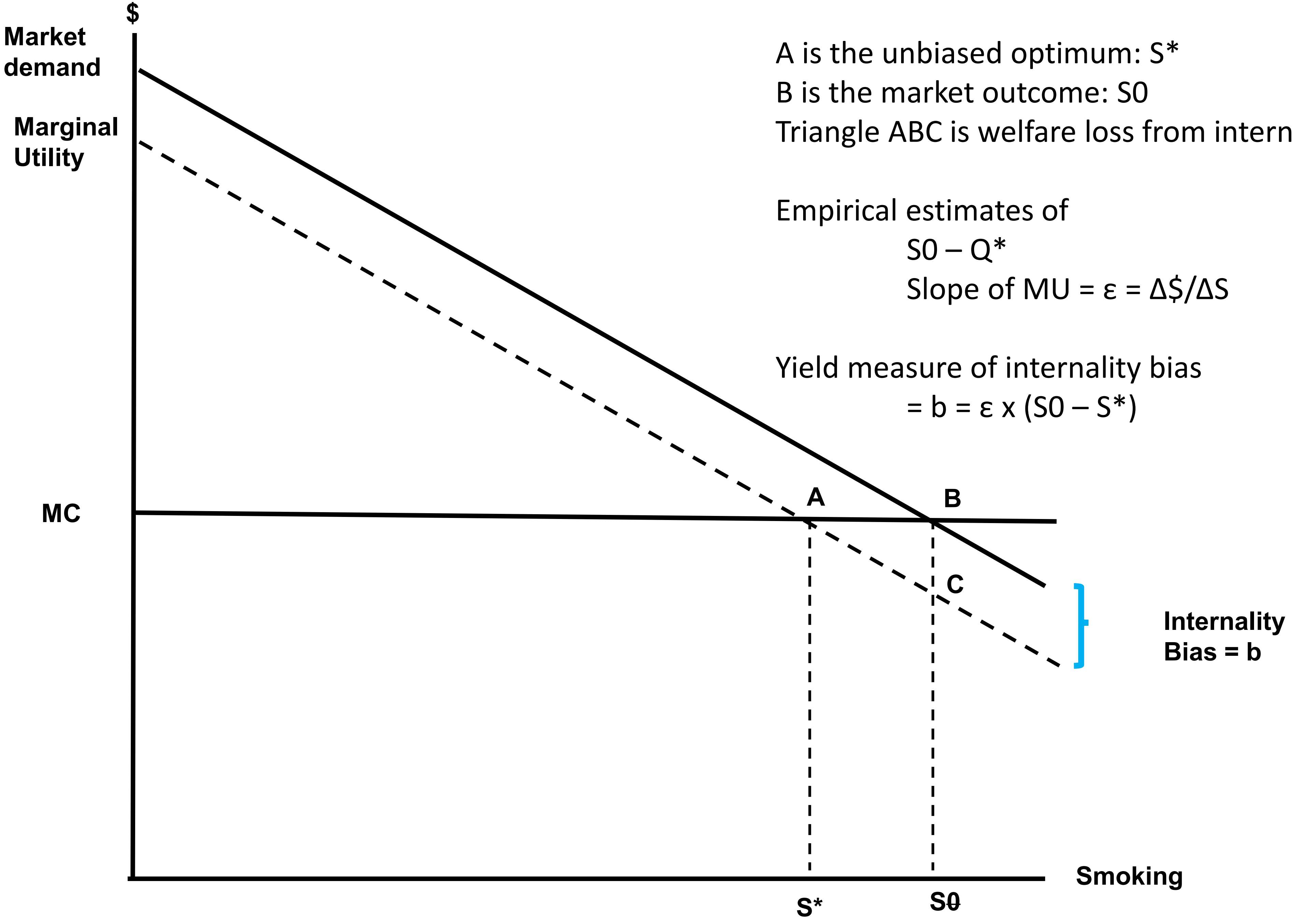
Approaches to estimate unbiased demand and internalities

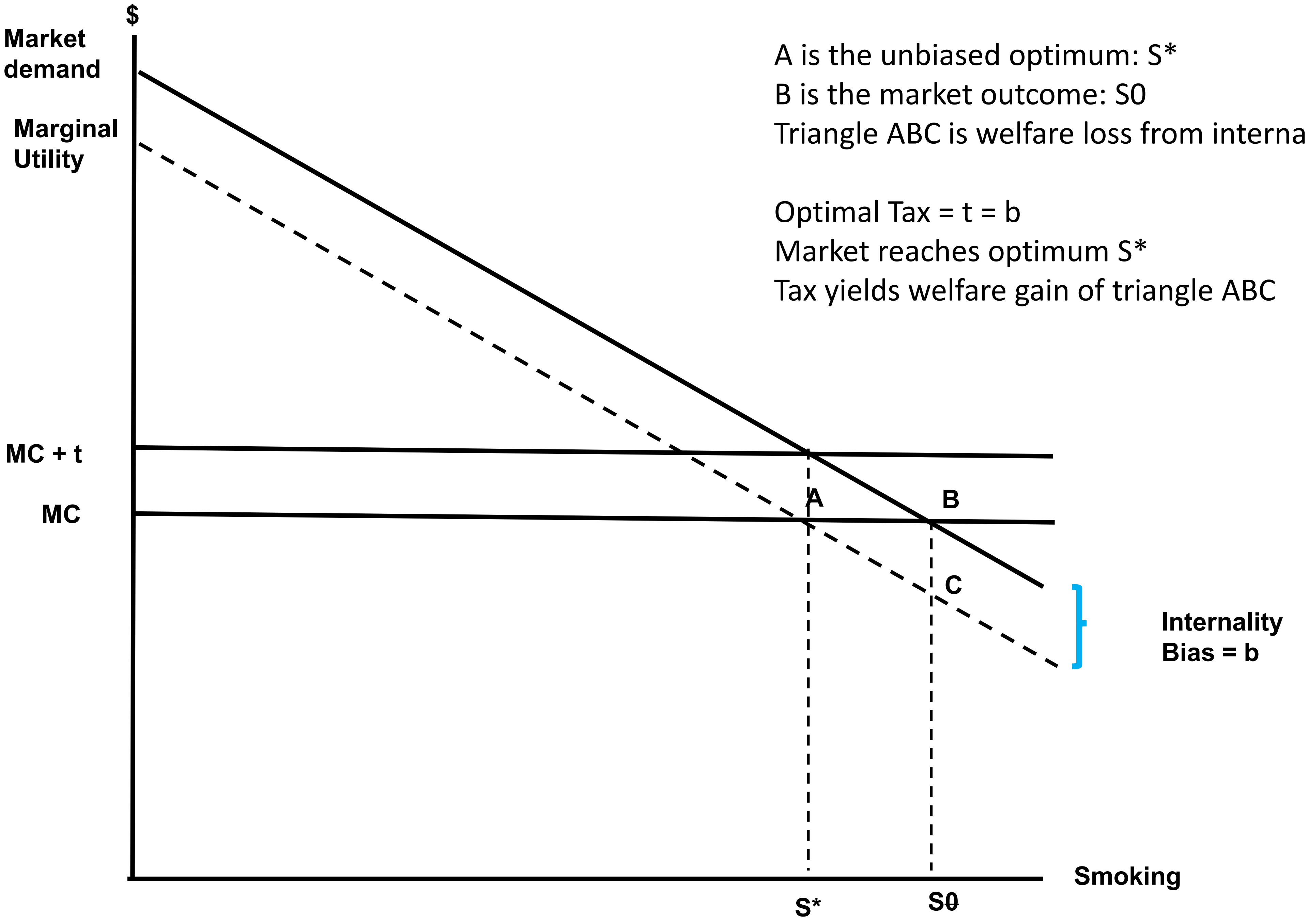
- Estimate the unbiased demand of a counter-factual normative consumer.
  - Allcott, et al. (2019) use measures of consumer nutrition information and responses to "I drink soda pop or other sugar-sweetened beverages more often than I should."
  - Schmaker and Smed (AEJ:EP 2023) use a psych validated self-control scale.
  - Jin et al. (JBCA 2015), Cutler et al. (2015 JBCA) identify demographic sub-groups likely to be able to align behavior with well-informed preferences.
- Use expert estimates to construct unbiased demand.
  - Gruber & Kocegi (QJE 2001) combine their estimate of the health costs of smoking and consensus estimates of β/δ discount rates.
  - Allcott et al. (2025) combine stated preference data on consumer willingness to pay for cars with different gas mileage with EPA estimate of gas mileage
  - Kenkel et al. (in progress) use SPs in DCEs on immediate and 6-month choices

A is the unbiased optimum: S*
B is the market outcome: S0
Triangle ABC is welfare loss from internality

Empirical estimates of
S0 – Q*
Slope of MU = ε = Δ$/ΔS

Yield measure of internality bias
= b = ε x (S0 – S*)





A is the unbiased optimum: S*
B is the market outcome: S0
Triangle ABC is welfare loss from internality

Optimal Tax = t = b
Market reaches optimum S*
Tax yields welfare gain of triangle ABC

Example 4: CBA of a nudge that changes tobacco product attributes, w/ internalities

- Nudge = requiring graphic warning labels on cigarette packages
  - Common in many countries, US reg will take effect in 2026
- Nudge imposes direct costs on consumers
  - Empirical evidence that labels work through fear & disgust, not by providing information => shifts down MU = unbiased demand for cigs
- Kenkel et al. (work-in-progress) use data from Discrete Choice Experiment
  - Estimate average internality = $4.15/pack
  - Estimate average WTP to avoid graphic warning label = $12.20/pack
  - Work-in-progress to capture heterogeneity in internalities & treatment effects

Please select one option.

	Cigarettes	E-Cigarettes	Neither
PRODUCT			
PRICE	20.00 USD	2 USD	
NICOTINE CONTENT	You will inhale between 22-38 mg of nicotine per pack of typical cigarettes if you smoke regulars, or between 12-20 mg of nicotine per pack if you smoke so-called mild or light cigarettes.	Various nicotine levels available, up to 20mg	**I will quit smoking cigarettes and not use e-cigarettes.**
FLAVOR	Your current cigarette flavor	Available flavors are tobacco, menthol, fruit/sweet/candy	
WARNING MESSAGE		This product contains nicotine, nicotine is an addictive chemical	

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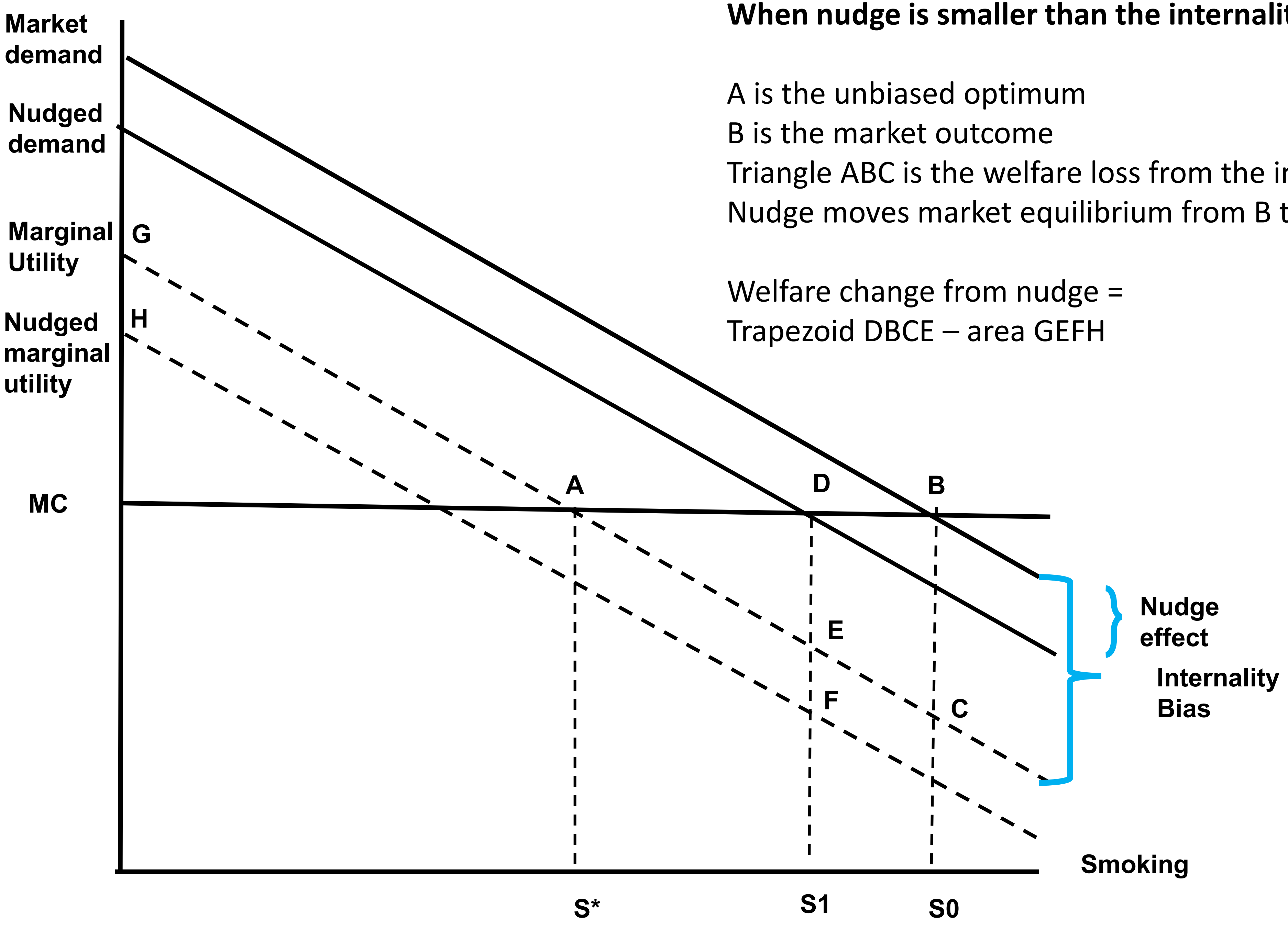
When nudge is smaller than the internality

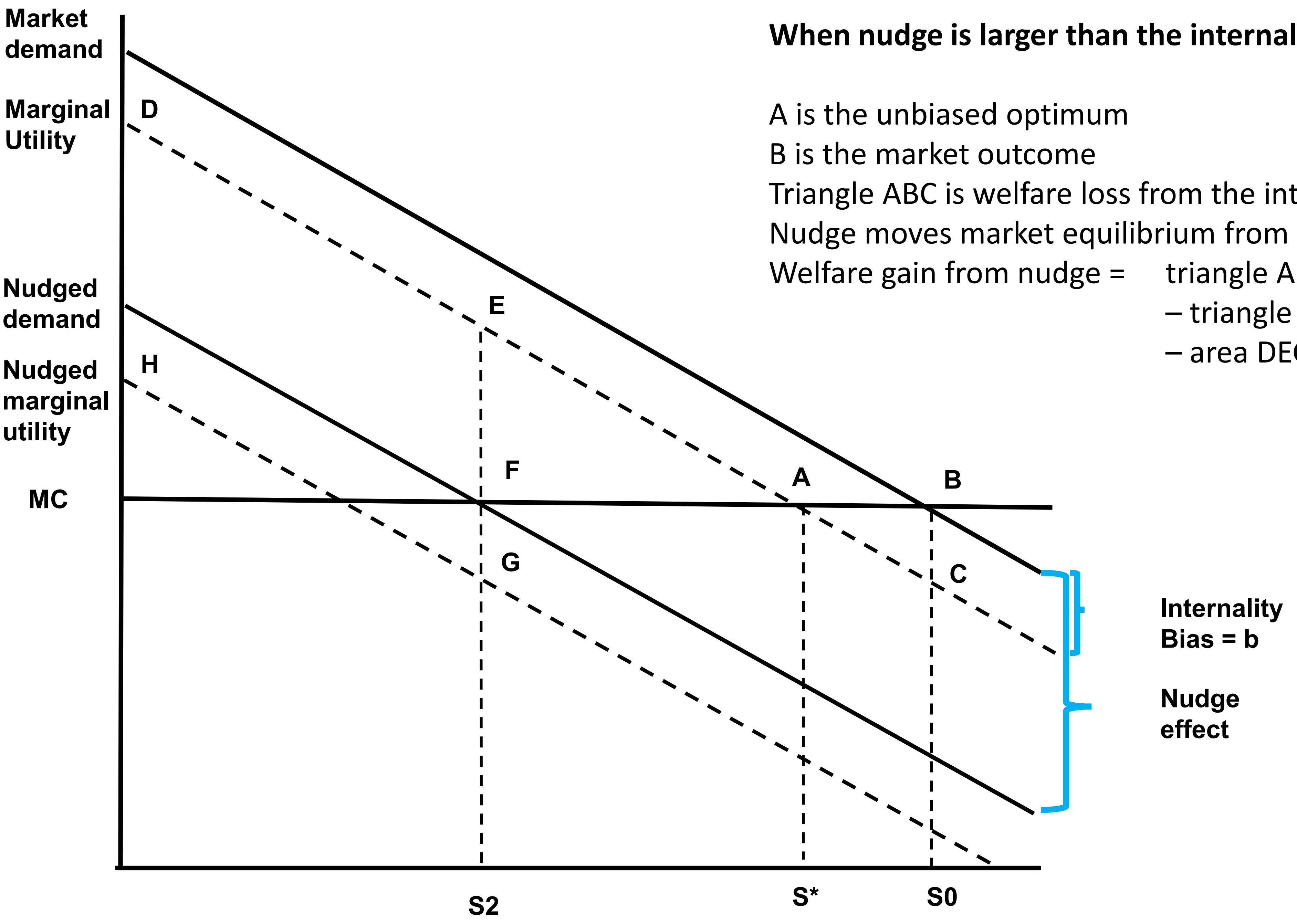
A is the unbiased optimum
B is the market outcome
Triangle ABC is the welfare loss from the internality
Nudge moves market equilibrium from B to D

Welfare change from nudge =
Trapezoid DBCE – area GEFH



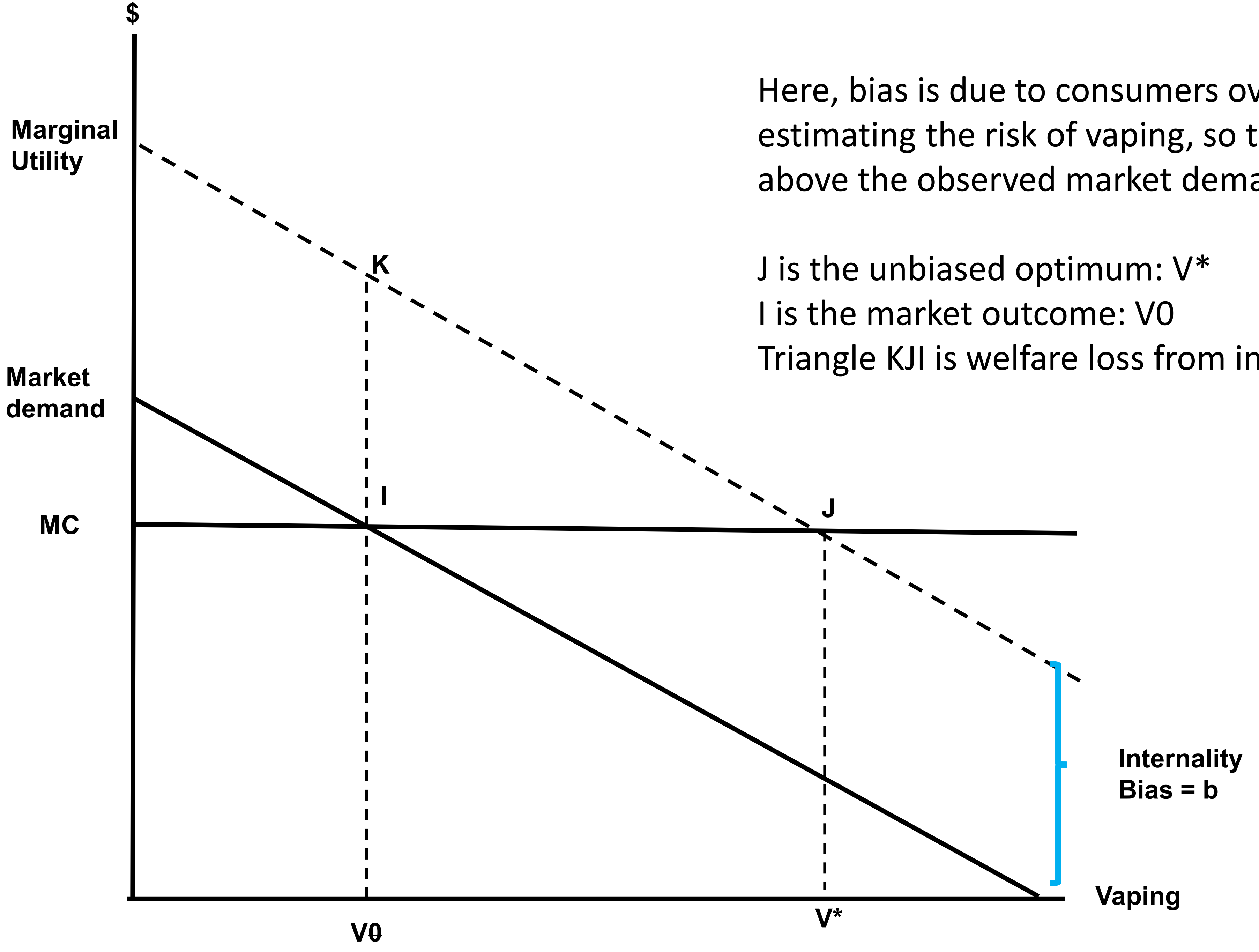
When nudge is larger than the internality

A is the unbiased optimum
B is the market outcome
Triangle ABC is welfare loss from the internality
Nudge moves market equilibrium from B to F
Welfare gain from nudge = triangle ABC
– triangle EAF
– area DEGH



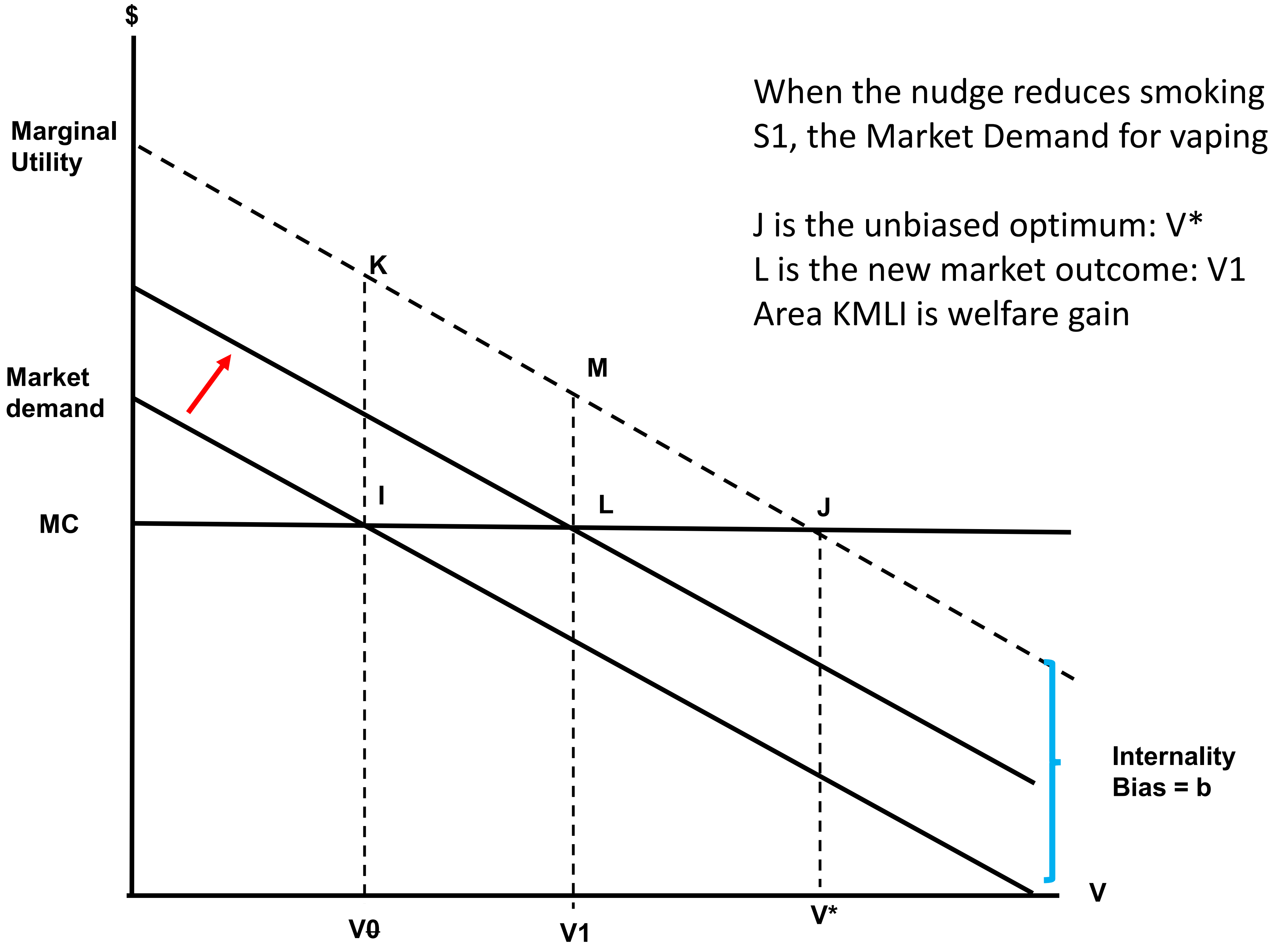
Preliminary Cost-Benefit Analysis

- Size of U.S. cigarette market = 10.688 billion packs
- Benefit of graphic warning labels = $0.39 billion
- Cost of graphic warning labels = $3.3 billion
- Benefits – Costs = -$2.94 billion
- Heterogenous treatment effects => graphic warning labels are poorly targeted because consumers with internalities don’t respond
  - I.e. graphic warning labels impose costs on rational consumers and don’t correct the behavior of consumers w/ internalities.
- Next step: extend analysis to include extra benefit of shifting smokers to vaping
  - Additional benefit because e-cig market is distorted by misinformation



Here, bias is due to consumers over-estimating the risk of vaping, so true MU is above the observed market demand.

J is the unbiased optimum: V*
I is the market outcome: V0
Triangle KJI is welfare loss from internality



When the nudge reduces smoking from S0 to S1, the Market Demand for vaping shifts up.

J is the unbiased optimum: V*
L is the new market outcome: V1
Area KMLI is welfare gain