Incidence and Equity:

(Or, Who Bears the Burden of Pollution and Policy?)

Lecture 6

ARE 264

February 3, 2022

Preparing for lecture 7

- Read Sallee 2020, and the accompanying referee reports to complete the bCourses prompt
- Read Allcott, Lockwood and Taubinsky 2018 (AER P&P, "Ramsey Strikes Back")

Lecture 4 Recap

1. **What is the rebound effect?**
    - Most often we mean: raising energy efficiency lowers cost of energy services and raises quantity demanded, which erodes conservation gains
    - Borenstein delineates several versions of rebound
2. **Why are performance standards not cost effective?**
    - Create rebound
    - Fail to correct market size
    - Used durable market interactions
3. **What are attribute-based standards?**
    - Performance standards that target one characteristic, but create a sliding scale based on some secondary attribute

Outline

1. **How do we incorporate equity into our analysis of environmental policy?**
   - The "optimistic separability" view suggests that efficiency and equity can be divorced and considered separately. This isn't entirely true, but it is an important perspective
2. **If we do care about equity, how might pollution and policy affect the distribution of welfare?**
   - Fullerton suggests several channels. This flags the need to understand incidence, including in general equilibrium
3. **Quick notes on incidence**
4. **How can we model the incidence of environmental policy?**
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Segue

- Suppose it is possible to implement a Pigouvian tax accurately and with zero administrative cost
- Does implementing that tax lead to the socially optimal outcome?

- This is a public service reminder that Pareto efficiency is not social optimality

- Even when the First Theorem of Welfare Economics is satisfied and outcomes are Pareto efficient, outcomes may be unfair

- As such, a policy that perfectly restores efficiency need not be the ideal policy instrument! There are other legitimate criteria

- **Our core question about equity:** If an efficient policy is regressive, should that stop us from adopting it, or cause us to modify it?

- Two views on how to answer this question:
  - **Conventional view:** we should take equity-efficiency trade-offs into account, so generally we would modify the Pigouvian prescription to account for equity goals
  - **Optimistic separability:** equity and efficiency are separable—in particular, if a policy is regressive, we can adjust other policies to preserve desired distribution

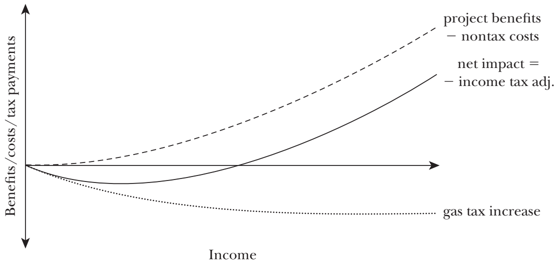
- Under optimistic separability, we get to have our cake and eat it too

Second welfare theorem of economics: given the right initial endowments, any Pareto efficient point can be achieved as a market equilibrium.

- What does that mean? Lump-sum redistribution plus competitive market outcome can produce any efficient allocation
- Richard Musgrave: three roles of government (efficiency, equity and stability) are completely separable
- **Punchline:** Don't redistribute with every policy; sometimes equity and efficiency are separable

- Louis Kaplow has a series of papers that develop this optimistic view
- Assigned JEP article argues:
  - Consider "benefit offsetting income tax adjustment" that pairs with an efficiency-enhancing action (providing a public good, correcting an externality) to preserve original distribution
  - This obviates need for worrying about (1) preferences over equity/distribution and (2) labor supply effects in deciding whether an action is worth taking
  - Moreover this can generate a Pareto improvement

Figure 1
Gasoline Tax Increase and Offsetting Income Tax Adjustment



- Initial incidence of gas tax is lower dotted line (regressive)
- High dashed line is benefits (reduced congestion, pollution) minus behavioral adjustments ⇒ Solid line is net
- Kaplow suggests a tax rebate/tax to exactly the solid line; this preserves original labor supply (payoff is the same as before at each level of income, choices won't change) and distribution of utility (everyone's cost is just offset)
- This will raise net revenue (by definition!), use for Pareto gain

Figure 4. Emissions ($mtCO_2$) per Capita by Alternative Measures

Panel A: Income Decile

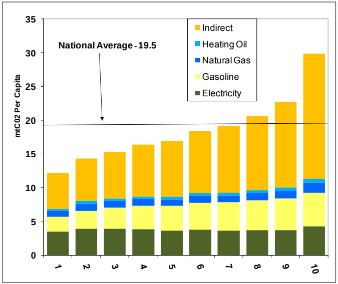
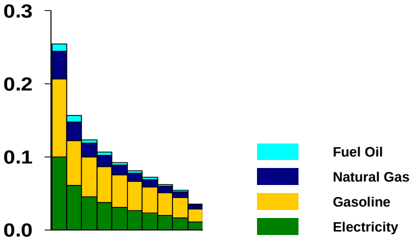
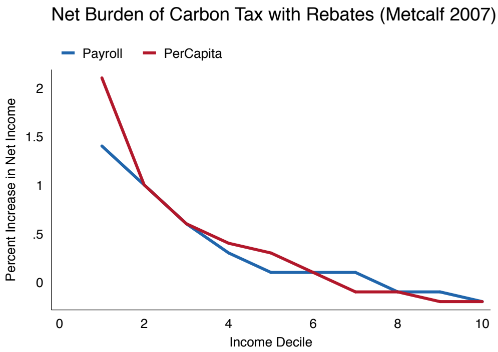


Figure 1. National Direct Energy Expenditures as a Fraction of Income



Source: Burtraw, Sweeney and Walls (2008)

- A good example is pricing carbon
- Lower income households in the US spend a larger fraction of their income on raw energy $\Rightarrow$ energy price raising policies are regressive



- It is not too hard to use revenue to ensure that environmental policies are progressive on average
- For example, per capita rebates or payroll tax cuts are sufficient to achieve progressivity
- My takeaway from the Kaplow view is that it is important to consider the use of revenue and the possibility of complementary policy reforms when assessing distributional implications

- For more formal treatments of this idea, see:
  - Kaplow, 2012. "Optimal Control of Externalities in the Presence of Income Taxation" *International Economic Review*
  - Gauthier and Laroque, 2009. "Separability and Public Finance" *Journal of Public Economics*

- Some critiques include:
  - Lockwood and Taubinsky, 2017. "Regressive Sin Taxes" NBER WP, which became Allcott, Lockwood and Taubinsky 2019
  - Sallee, 2020. "Pigou Create Loser"

What's the take away from Kaplow's view?

- We will discuss the breakdown of this result later. In brief, the Kaplow argument assumes preference homogeneity—differences in consumption are all due to income differences.

- Regardless of such critiques and weakness, the deeper Kaplow point is that it doesn't necessarily make sense to consider an environmental policy in isolation. Why not consider a package that reforms an income tax or a welfare program in conjunction with the environmental policy?

- This is especially logical when the instrument is a tax or permit scheme that raises revenue

What's the conventional view?

- The conventional view is that we should tailor our corrective policies to account for the distribution of its impacts
- This is easy to say in theory, but it requires tools and assumptions

- The next few slides are a quick reminder of some high level issues that have to be resolved to turn equity considerations into quantitative results

Arrow's Impossibility Theorem

Arrow (1951) proved that no social choice function can generally satisfy all of these criteria:

1. Completeness: all allocations can be ranked
2. Unanimity: if all individuals prefer *a* to *b*, then society prefers *a* to *b*
3. Nondictatorship: no one individual's preferences are equal to society's
4. Universality: any individual preference ordering is permitted
5. Transitivity: If *a* is preferred to *b* and *b* is preferred to *c*, then *a* is preferred to *c*
6. Independence of irrelevant alternatives: Ranking of *a* and *b* is unaffected by availability of *c*

Punchline: determination of social preferences requires taking a stance on preference aggregation

Pareto efficiency

An allocation is Pareto efficient if no other feasible allocation makes everyone no worse off and someone better off.

- Pareto efficiency is a partial ordering
- Can be said to bias towards status quo
- Most economies will have an infinite number of Pareto efficient allocations, Pareto efficiency offers no insight as to how to compare such allocations

Alternative definitions of efficiency

Kaldor-Hicks compensation criterion: A change from allocation A to B is preferred if a set of hypothetical transfers exists that could be made that would ensure no one was worse off under A and someone is made better off.

- Pareto efficiency $\neq$ making the pie bigger
- Kaldor-Hicks $=$ making the pie bigger

The Social Welfare Function

- Efficiency definitions don't tell us how to trade off efficiency and equity. Need something else.

- Bergson-Samuelson Functional provides complete ordering
- Social Welfare Function (SWF) takes utilities of individuals as arguments: $W = W(U^1, ..., U^I)$
- Most commonly, just take a weighted sum: $W = \sum_{i=1}^{I} \omega_i U^i$ where ω_i are welfare weights assigned to each individual
- Utilitarian SWF maximizes simple sum of utilities

- This approach is extremely useful, but it requires the interpersonal comparison of utility functions, which is a major departure from basic microeconomics

The Social Welfare Function

Source: Wikipedia

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- Suppose we do want to worry about the distributional implications of a pollution or policy. How should we do it?

- Fullerton (2011) provides useful framework for thinking about all of the channels of distributional effects
- Example is carbon taxation, but most pieces apply quite broadly
- Question: what are the channels through which environmental policy might have impacts on welfare?
- What are their likely distributional impacts?

Six distributional effects (Fullerton 2011)

- **What are the channels through which environmental policy might have impacts on welfare?**

1. Higher prices for goods
2. Changes in factor returns (labor, capital, land)
3. Allocation of rents from permits (revenue from a tax)
4. Distribution of the benefits of environmental quality
5. Temporary effects during transition
6. Capitalization of all effects into prices for land, stocks, house values, etc.

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We need tools for assessing incidence

- Supplemental video on incidence covers a bit of intuition on tax incidence

1. Who cares who pays?
2. People pay taxes
3. Inelasticity is expensive
4. In general, anything can happen

   Credit: Jim Hines

Incidence with imperfect competition

- Incidence results stated above were all derived assuming perfect competition
- Can we extend or modify the results under other forms of competition?

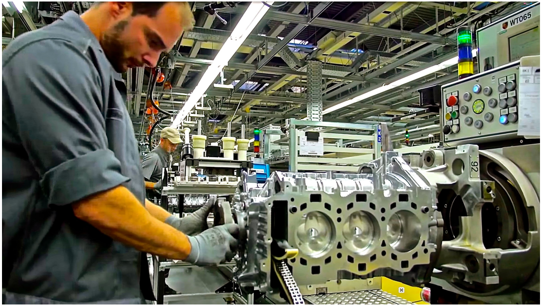
- Weyl and Fabinger "Pass-Through as an Economic Tool: The Principles of Incidence under Imperfect Competition" (JPE 2013) provide collection of relevant results.
- Emphasize pass through rate (how much do consumer prices rise from increase in tax) as sufficient statistic for welfare (envelope theorem—note that you can integrate to consider non-marginal changes)
- Consider various forms of competition (PC, monopoly, oligopoly)

- **Weyl and Fabinger paper is full of useful tools and insights**

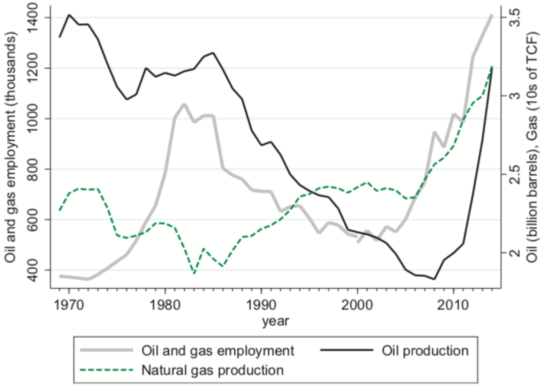
General equilibrium incidence

- Harberger (1962) provides a tractable framework for understanding general equilibrium tax incidence, but it makes many strong assumptions
- Log-linearization structure provides a method for getting analytical solutions (see Fullerton and Metcalf "Tax Incidence" for a guide)
- This is not "easy", but it is manageable

- Other policies could be fit into this framework
- Assumptions can be relaxed; allow heterogeneity, market power, open economy, etc.
- There is a large literature in PF that extends Harberger, so there are templates



- Suppose you put a tax on robots (manufacturing capital)
- The burden of that tax might fall primarily on workers who are complements in production, rather than on the capital
- Likely true if workers are not very mobile (Inelasticity is Expensive!)
- The burden of a tax can be born in a market, factor or country different from where the tax is: we say **"In general, anything can happen"**



Allcott and Keniston (2018)

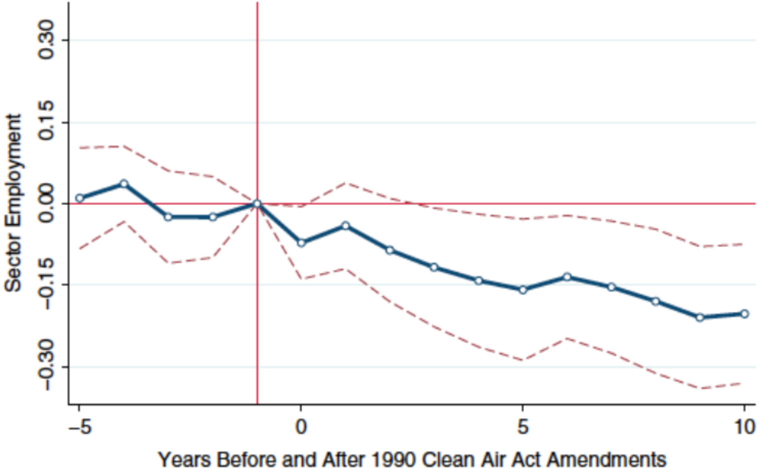
- Economists often study market fluctuations around a good as natural experiments that show what would happen if a policy impacted that market
- Allcott and Keniston study fracking boom

- Fracking boom caused big increase in employment in oil and gas
- There are many possible **general equilibrium** effects of this employment boom:
  - Manufacturing may decline (workers shift to fracking)
  - Construction jobs to build new housing
  - Service jobs (e.g., restaurants) in local area
  - Changes in property values
  - Changes in crime

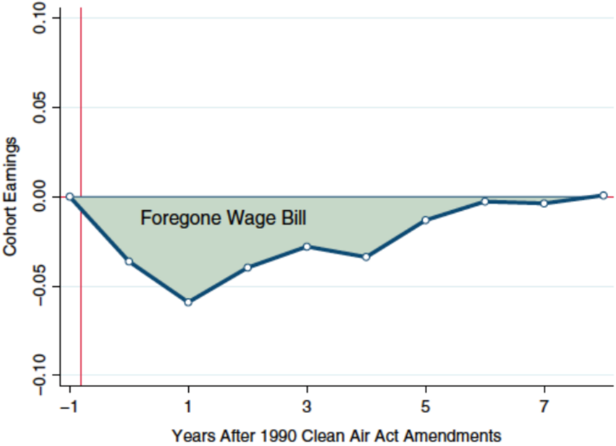
- Allcott and Keniston (2018) find that fracking caused decrease in manufacturing employment, but no evidence that wages fell

CAA reduces employment in regulated sectors

Employment falls about 15% in regulated sectors relative to unregulated sectors 5 years after regulation



Source: Walker (2013)



Source: Walker (2013)

- Workers see wage reductions. Eventually, workers change jobs and sectors and eventually recover in their annual earnings, but they never "catch up" on what they lost in the several years after regulation

- Past research has shown the following affects of the CAA:
  - Nonattainment counties have lower growth rates in regulated sectors
  - New plants less likely to open in nonattainment counties
  - Workers lose employment and wages
  - Regulated firms are less productive

  Source: Currie and Walker (2019)

- Impacts on workers are just one example of general equilibrium effects. Regulation imposed on firms impacts workers **"in general, anything can happen"**
- It is also a version of **"people pay taxes"**. Regulation imposed on firms impacts workers

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Tax theory and environmental policies

- Two closely related papers on the syllabus by Fullerton and Heutel modify the Harberger model to assess the incidence of environmental policy
- The first addresses and environmental tax; the second addresses non-tax policies

What is the key point in Fullerton and Heutel models?

- Some of these models will get a little confusing (at least for me!)
- The main take away I want you to get:
  - A sense of the different **channels**—output effect, factor substitution effects, etc.—that are relevant for general equilibrium
  - A sense of how to adapt alternative policies into an incidence model
  - An example of “cross field arbitrage”
  - Some humility—“in general, anything can happen” (see Goulder, Hafstead and Williams in future lecture)

Fullerton and Heutel 2007

- How might we introduce pollution into the Harberger model?

- Fullerton and Heutel add pollution Z as an input

$$
\begin{aligned}
X &= X(K_X, L_X) \\
Y &= Y(K_Y, L_Y, Z)
\end{aligned}
$$

- Price of pollution is just tax τ_Z
- No limit on pollution

- Fixed K and L (just shift between sectors); perfect competition; constant returns to scale
- Use log-linearization: hats denote proportional changes; e.g., $\hat{K_X} \equiv dK_X/K_X$

Key objects that allow us to interpret results

- Allen elasticity (constant output) of substitution for inputs $\mathrm{e_{ij}}$
  - I.e., how much does demand for i rise in response to rise in price of j, holding output fixed
  - $e_{ij} > 0$ for substitutes; $e_{ij} < 0$ for complements
- Factor shares of revenue by sector $\theta_{sector,factor}$
  - E.g., $\theta_{YZ} = \tau_Z Z/(p_Y Y)$
  - Analogous factor shares for other factors, sectors
  - Factor shares within sector add to 1 ($\theta_{YK} + \theta_{YL} + \theta_{YZ} = 1$)
- Factor intensities, written as ratios of dirty/clean γ_{factor}
  - $\gamma_K \equiv K_Y/K_X$; higher ratio implies more of K goes to Y
  - If $\gamma_{\mathrm{K}} - \gamma_{\mathrm{L}} > 0$ then dirty good is <u>K intensive</u>
- Elasticity of demand between goods Y and Z: σ_{u}

$$\hat{p}_Y = \frac{(\theta_{YL}\theta_{XK} - \theta_{YK}\theta_{XL})\theta_{YZ}}{D}[A(e_{ZZ} - e_{KZ}) - B(e_{ZZ} - e_{LZ}) + (\gamma_K - \gamma_L)\sigma_u]\hat{\tau}_Z + \theta_{YZ}\hat{\tau}_Z \tag{11a}$$

$$\hat{w} = \frac{\theta_{XK}\theta_{YZ}}{D}[A(e_{ZZ} - e_{KZ}) - B(e_{ZZ} - e_{LZ}) + (\gamma_K - \gamma_L)\sigma_u]\hat{\tau}_Z, \tag{11b}$$

$$\hat{r} = \frac{\theta_{XL}\theta_{YZ}}{D}[A(e_{KZ} - e_{ZZ}) - B(e_{LZ} - e_{ZZ}) - (\gamma_K - \gamma_L)\sigma_u]\hat{\tau}_Z, \tag{11c}$$

$$\begin{aligned} \hat{Z} = -\frac{1}{C}[&\theta_{YK}(\beta_K(e_{KK} - e_{ZK}) + \beta_L(e_{LK} - e_{ZK}) + \sigma_u)\hat{r} + \theta_{YL}(\beta_K(e_{KL} - e_{ZL}) \\ &+ \beta_L(e_{LL} - e_{ZL}) + \sigma_u)\hat{w} + \theta_{YZ}(\beta_K(e_{KZ} - e_{ZZ}) \\ &+ \beta_L(e_{LZ} - e_{ZZ}) + \sigma_u)\hat{\tau}_Z] \end{aligned} \tag{11d}$$

- A, B, C and D are additional terms, substituted for readability
- Results describe incidence of a change in tax rate on pollution τ_Z
- To understand incidence, just want to know how prices change

Interpretation: three basic pieces

- Output effect is $(\gamma_K - \gamma_L)\sigma_u$—pollution tax raises cost of Y
  - This harms factor used intensively in dirty sector
  - Effect larger as σ_u larger

- First two terms (with e terms) inside brackes in 11b and 11c are substitution effects
  - Impact of a tax on Z depends on own-price elasticity of factor demand as it compares to cross-price elasticities

- Factors in front of brackets are about factor intensities...but hard to interpret generally

- Paper emphasizes that general results are complex—but that is partly the point, lots of things are possible in general equilibrium

Interpretation: special cases, numerical analysis

- Paper then describes special cases that simplify the analytical formula, as well as some numerical results
- Many results are intuitive, but some are surprising ("in general, anything can happen"):
  - Suppose capital a better substitute for pollution, while both sectors equally capital intense: if labor and capital are highly complementary, then capital can still lose relative to labor from a tax
  - Suppose capital and labor equal substitutes for pollution, but dirty good is capital intensive: pollution tax can benefit capital when substitution between sectors is smaller than substitution between factors
  - A pollution tax can increase pollution (but only for extreme cases); more generally, the change in pollution depends on a host of parameters

- Fullerton and Heutel (2007) considers a tax
- But, lots of policies are not a tax
- Lots of policies that are not actually a tax can still be understood as a tax

Fullerton and Heutel (2010)

- Fullerton and Heutel (2010) study general equilibrium incidence of environmental mandates
- Same setup as Fullerton and Heutel (2007), but different policies
- Two sectors: one clean and one dirty

$$X = X(L_X, K_X) \quad Y = Y(L_Y, K_Y, Z)$$

where Z is pollution

- Model **performance standard** as limit on emissions per unit of output: $Z/Y \leq \delta$
- Model **technology mandate** as limit on emissions per unit of capital: $Z/K_Y \leq \zeta$

Performance standard

- Dirty firm solves:

$$\max_{K_Y, L_Y, Z} p_Y Y(K_Y, L_Y, Z) - rK_Y - wL_Y$$
$$\text{s.t. } Z/Y \leq \delta$$

- Pollution tax model (and original Harberger model) has output effect; a pollution tax will shift demand from Y toward X; this lowers relative factor price for factor used intensively in dirty production
- Performance standard creates new output-subsidy effect: constraint is relaxed by increasing Y; which benefits factor used intensively in Y
- Performance standard taxes pollution **but subsidizes output** (same insight as Holland, Hughes and Knittel, to be discussed later)

Output-subsidy effect

$$\hat{r} = \left[-\frac{\theta_{XL}\nu}{D}(\gamma_K - \gamma_L) + \frac{\theta_{XL}\nu\sigma_u}{D}(\gamma_K - \gamma_L) + \frac{\theta_{XL}\eta}{D} b_\delta \right] \hat{\delta}$$

$$\hat{w} = \left[\frac{\theta_{XK}\nu}{D}(\gamma_K - \gamma_L) - \frac{\theta_{XK}\nu\sigma_u}{D}(\gamma_K - \gamma_L) - \frac{\theta_{XK}\eta}{D} b_\delta \right] \hat{\delta}$$

- The first and third term are the same as under a tax
- The middle term here is the new term, representing the **output-subsidy effect**
- If $\sigma_u > 1$, then the output-subsidy effect dominates and lead to improvements for the factor that is demanded intensively in the dirty sector

Technology mandate

- Dirty firm solves:

$$\max_{K_Y, L_Y, Z} p_Y Y(K_Y, L_Y, Z) - rK_Y - wL_Y$$
$$\text{s.t. } Z/K_Y \leq \zeta$$

- This subsidizes K: K directly increases production, but it also allows more pollution (which raises production)
- A **capital-subsidy effect** creates an effect that favors K over L in the dirty sector
- By subsidizing K used in dirty sector, this creates the same type of output-subsidy effect as under the performance mandate

Summary of effects

TABLE 3—THE SIGN OF EACH EFFECT ON THE RATE OF RETURN TO CAPITAL[a]

Type of restriction	Substitution effect	Output effect	Output-subsidy effect	Capital-subsidy effect
Quantity[b] Z	$e_{KZ} - e_{LZ}$	$(\gamma_L - \gamma_K)$		
Ratio Z/Y	$e_{KZ} - e_{LZ}$	$(\gamma_L - \gamma_K)$	$(\gamma_K - \gamma_L)$	
Ratio Z/K_Y	$e_{KZ} - e_{LZ}$	$(\gamma_L - \gamma_K)$	$(\gamma_K - \gamma_L)$	$e_{KL} - e_{KK}$

[a] The effect on the wage rate always has the opposite sign.
[b] The quantity policy is considered in the Appendix.

- This table provides the key intuitions. These effects have "weights" in the formula.
- Substitution effect raises r ($=$ lowers w) if capital is a better substitute for pollution
- Output effect raises r if dirty sector is labor intensive
- Output-subsidy effect raises r if dirty sector capital intensive
- Capital-subsidy effect raises r

Summing up

- These papers meant to emphasize value of **analytical** results from GE models
- They emphasize some core mechanisms:
  - Output effect: restricting pollution bad for factor used intensively in dirty sector
  - Substitution effect: factor complementary to pollution bears more burden
  - Performance standard: output-subsidy effect benefits factor used intensively in dirty sector
  - Technology mandate: capital-substitution effect benefits capital
- But, they also emphasize that counterintuitive results can happen (in general, anything can happen)

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