The Design of Border Carbon Adjustments

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Fall 2015

Substantial prior literature

- Studies on design of border adjustments.
- Studies on effects.
  - Mostly CGE.
- Legislative language.
  - Studies of the legislation.

Sample of prior literature on design

- Branger, Frédéric, and Philippe Quirion. 2014. "Would Border Carbon Adjustments Prevent Carbon Leakage and Heavy Industry Competitiveness Losses? Insights from a Meta-Analysis of Recent Economic Studies." *Ecological Economics* 99 (March): 29–39.
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Statutory language

- Waxman Markey
  - Analysis of Waxman Markey: The Effects of H.R. 2454 on International Competitiveness and Emission Leakage in Energy-Intensive Trade-Exposed Industries, An Interagency Report (2009).
- Lieberman Warner
- EU proposals

Our strategy

- Review this literature for basic lessons.
- Use simple analytic model to better understand core economics.
  - See how the lessons from the literature apply in a simple setting.

Basic Design Considerations

Lessons from the literature

- Very hard to impose border adjustments except on a limited set of industries.
  - Even within the five most energy intensive, trade-exposed industries, hundreds of different goods.

- No simple measure of emissions.
  - Don’t have a coherent concept of emissions when exporting country has multiple sources of energy.
  - Production processes vary widely for a given type of good.
  - Only choice is crude proxies.

- Choice of which countries are subject to border taxes will be controversial and political. There are no objective criteria.

- In technical terms, you have to be crazy to want to do this.

In theory

- BTA's are a tax on emissions from the production of an imported good and a rebate on export of prior taxes paid.
- Converts a tax on domestic production to a tax on domestic consumption.
  - Or a tax on domestic extraction into a tax on either production or consumption.
- Addresses leakage via a shift in location of activity.
  - Consumption location less elastic than production.
- Does not address changes in activities abroad due to lower fossil fuel prices. E.g., increased production for consumption abroad.

Three basic choices for implementing BTA

- What goods?
  - All goods?
  - Goods most likely affected by a tax? How is this measured?
- Which emissions?
  - Direct, electricity, all?
  - How is this measured? What information is needed?
- From which countries?
  - All countries or countries without comparable carbon regimes?
  - But how do we determine what is “comparable”?

(Focus on tax on imports. Rebate on exports is easier.)

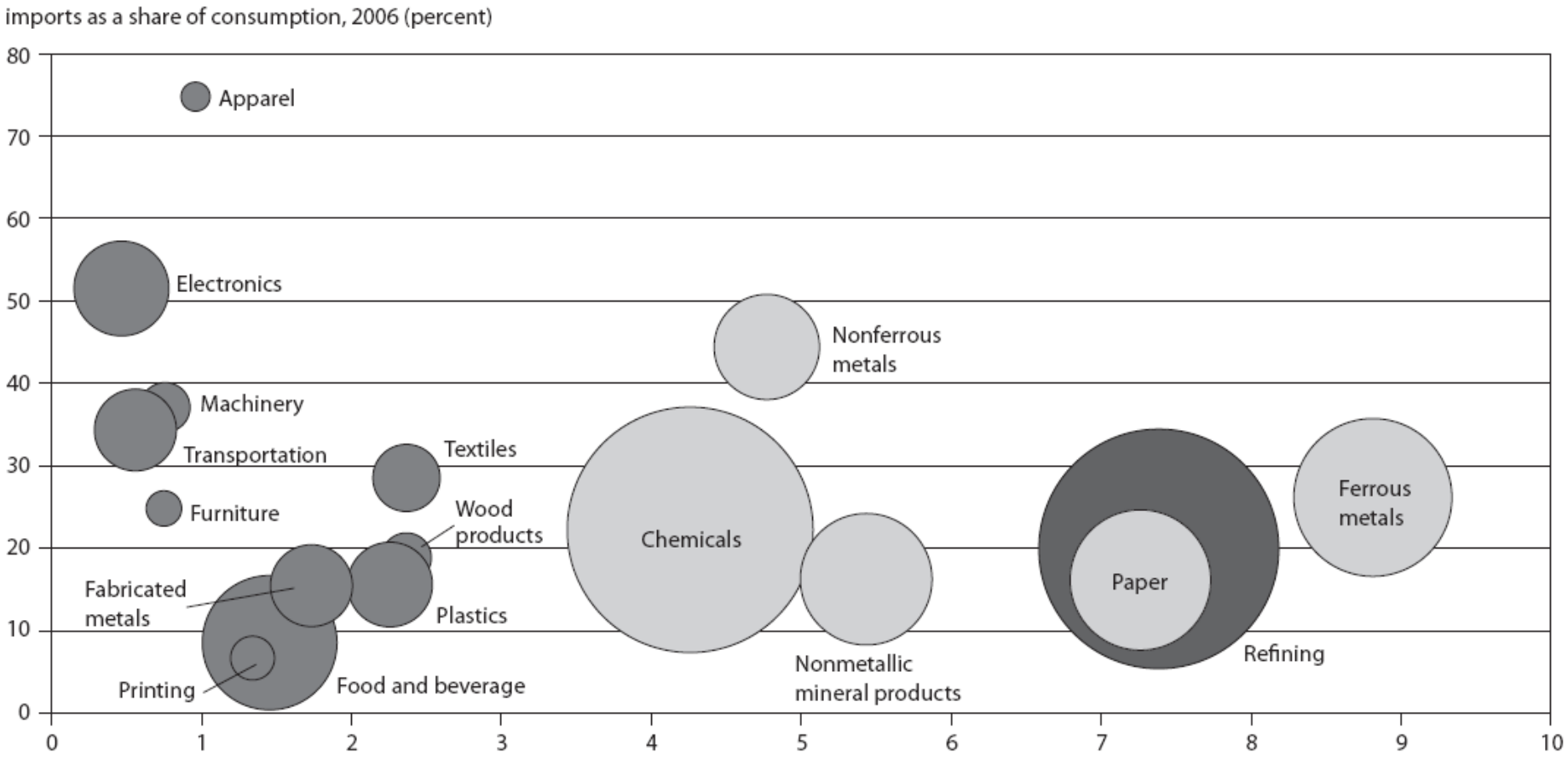
Which goods?

- Too complicated to impose border taxes on all goods or even a large subset of goods.
- Focus on places where production likely to shift abroad.

- Energy/GHG intensive.
- Trade exposed.

Energy intensive, trade exposed industries

Figure 1.3 US industry exposure to climate costs based on energy intensity and imports as a share of consumption

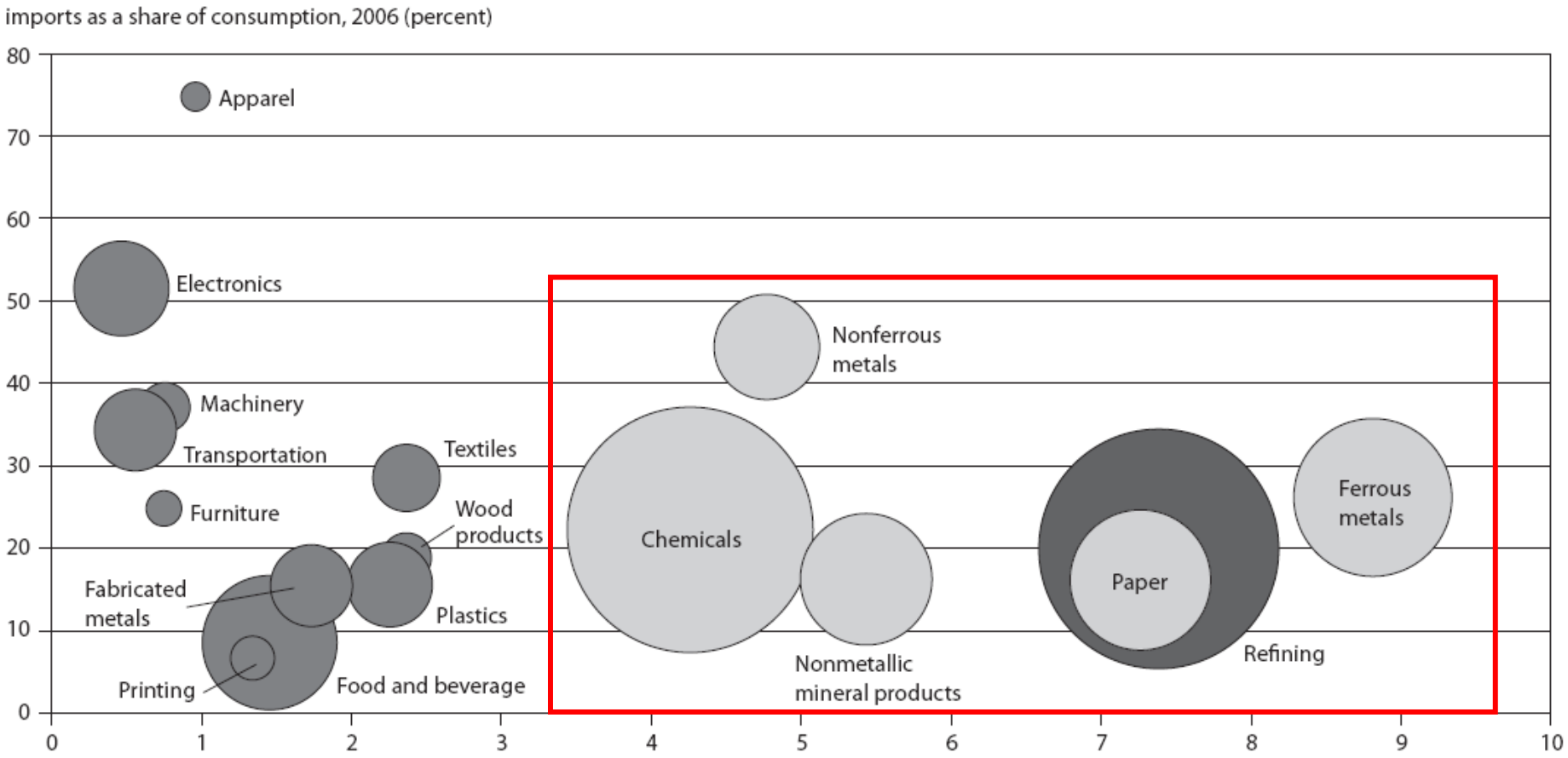


Note: The size of the bubbles indicates the total CO_2 emissions from the industry in 2002.

Source: Houser et al (2008)

Energy intensive, trade exposed industries

Figure 1.3 US industry exposure to climate costs based on energy intensity and imports as a share of consumption

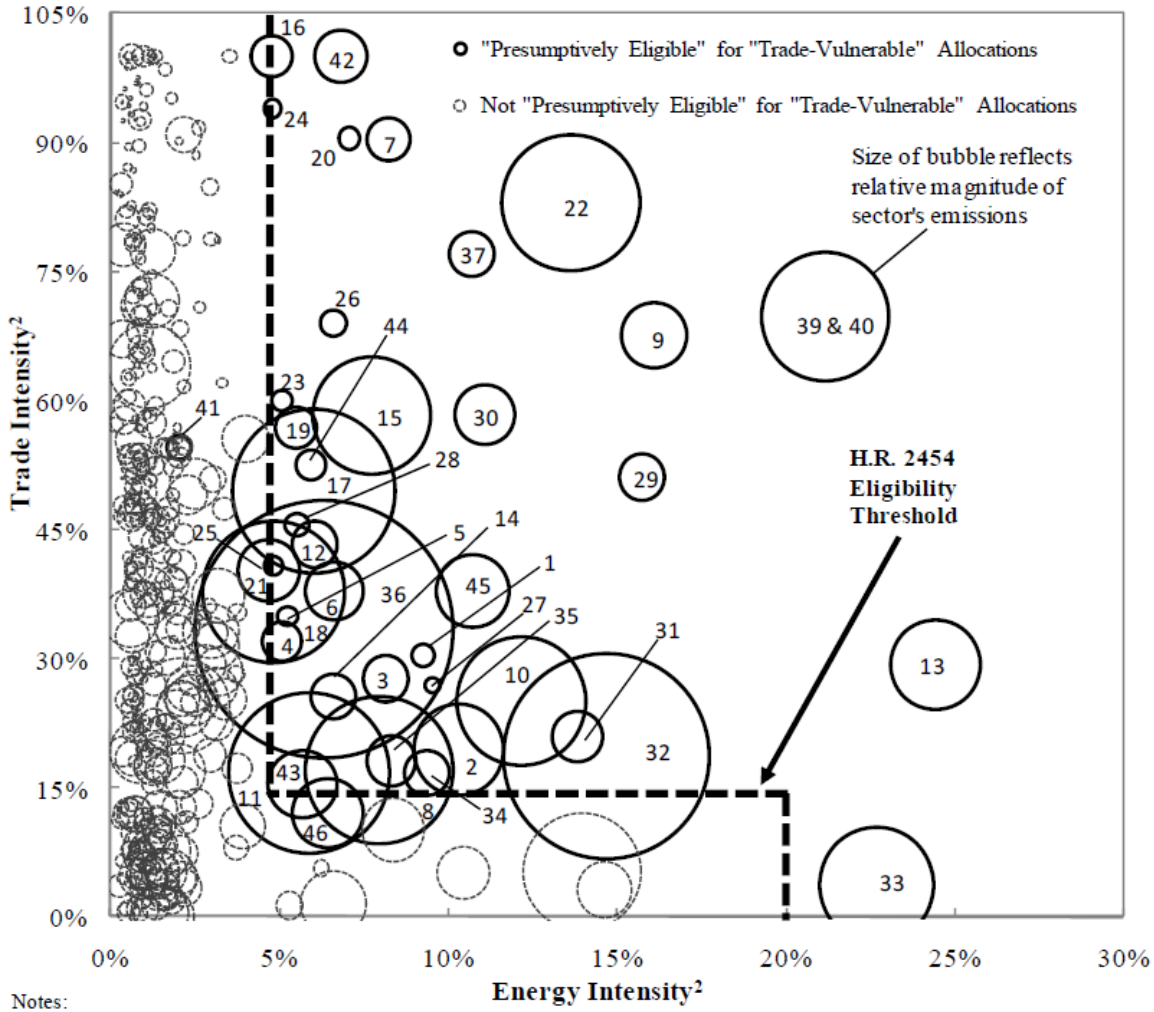


Note: The size of the bubbles indicates the total CO_2 emissions from the industry in 2002.

Source: Houser et al (2008)

Waxman Markey version – 46 industries

Figure 2. Energy Intensity, Trade Intensity, and Emissions of U.S. Manufacturing Sectors at the Six-Digit NAICS Code Level[1]



Notes:
1. Petroleum refining is not depicted because it is explicitly excluded from H.R. 2454's allocations to "trade-vulnerable" industries. Also, 91 other sectors, with 130 $MMTCO_2e$ of emissions, are not depicted due to lack of trade intensity data. One of these, iron and steel pipe and tube manufacturing from purchased steel (331210; 2.6 $MMTCO_2e$) is expected to be eligible based on language in the bill. Four others meet the energy-intensity threshold, each with 2 to 3 $MMTCO_2e$ of emissions: beet sugar manufacturing, broadwoven fabric finishing mills, steel foundries (except investment), and metal heat treating. Twelve sectors with a calculated trade intensity greater than 100% are depicted here with an intensity of 100% (the maximum possible intensity). The two copper sectors (212234 and 331411) do not meet the energy or trade intensity thresholds specified in H.R. 2454 but are expected to be eligible based on other language in the bill.
2. Energy intensity and trade intensity measures are as defined in H.R. 2454 and elsewhere in this report.
Source: EPA analysis.

1. Malt Manufacturing (311213)
2. Wet Corn Milling (311221)
3. Rendering and Meat Byproduct Processing (311613)
4. Yarn Spinning Mills (313111)
5. Tire Cord and Tire Fabric Mills (314992)
6. Reconstituted Wood Product Manufacturing (321219)
7. Pulp Mills (322110)
8. Paper (except Newsprint) Mills (322121)
9. Newsprint Mills (322122)
10. Paperboard Mills (322130)
11. Petrochemical Manufacturing (325110)
12. Inorganic Dye and Pigment Manufacturing (325131)
13. Alkalies and Chlorine Manufacturing (325181)
14. Carbon Black Manufacturing (325182)
15. All Other Basic Inorganic Chemical Mfg. (325188)
16. Cyclic Crude and Intermediate Manufacturing (325192)
17. All Other Basic Organic Chemical Mfg. (325199)
18. Plastics Material and Resin Manufacturing (325211)
19. Synthetic Rubber Manufacturing (325212)
20. Cellulosic Organic Fiber Manufacturing (325221)
21. Noncellulosic Organic Fiber Manufacturing (325222)
22. Nitrogenous Fertilizer Manufacturing (325311)
23. Vitr. China Plumbing Fixture and Other Mfg. (327111)
24. Vitreous China and Other Pottery Mfg. (327112)
25. Porcelain Electrical Supply Manufacturing (327113)
26. Ceramic Wall and Floor Tile Manufacturing (327122)
27. Other Structural Clay Product Manufacturing (327123)
28. Nonclay Refractory Manufacturing (327125)
29. Flat Glass Manufacturing (327211)
30. Other Pressed/Blown Glass and Glsswr. Mfg. (327212)
31. Glass Container Manufacturing (327213)
32. Cement Manufacturing (327310)
33. Lime Manufacturing (327410)
34. Ground or Treated Mineral and Earth Mfg. (327992)
35. Mineral Wool Manufacturing (327993)
36. Iron and Steel Mills (331111)
37. Electrometallurgical Ferroalloy Product Mfg. (331112)
38. Iron/Steel Pipe/Tube Mfg. from Purchsd. Steel (331210)
39. Alumina Refining (331311)
40. Primary Aluminum Production (331312)
41. Primary Smelting and Refining of Copper (331411)
42. Smltg./Rfg. of Nonfrs. Mtl. (ex. Cpr. and Almn.) (331419)
43. Iron Foundries (331511)
44. Carbon and Graphite Product Manufacturing (335991)
45. Iron Ore Mining (212210)
46. Copper Ore and Nickel Ore Mining (212234)

Just five, just 46, or more?

- 46 6-digit NAICS codes meet W/M criteria.
- Within each 6-digit NAICS code, wide variety of products.

- "Other basic inorganic chemicals" (352180)
  - 198 different chemicals.
- "Plastics and resins" (325211)
  - 82 different products.
- "Iron and Steel" (331110)
  - 91 different products.

- Probably hundreds of different products (from dozens of countries).
- Each product from each country (or each producer within each country) might need a different measure of emissions.

Final goods or just raw materials?

- Large percentage of imported emissions comes from final goods.
  - E.g., automobiles.
- BTA's for final goods would be difficult.
  - What are the emissions from the manufacturing of an automobile?
- But emissions as percent of value for final goods is low.
  - So maybe carbon tax would have modest or small effects on location of production.
  - Won't need BTA's.
- W/M approach: set criteria for trade-exposed, energy-intensive.
  - Don't specifically exclude final goods, but few if any final goods would meet the criteria.
- Alternative: categorical exemption.

Emissions

- For each product have to measure the emissions.
- Ideally, actual emissions.
  - For each country, for each product, for each producer, for each factory . . .
- Two factors determine emissions:
  - Type of fuel used.
  - Production process.

Type of fuel used

- Example:
  - F has two sources of energy: hydro and coal.
  - Producer in F uses coal to manufacture goods for export to H. Suppose 100 units of emissions created during this process.
  - Hydro is used for domestic consumption in F. No emissions.

- What are the emissions associated with the export goods?

- Do they change if the producer switches to hydro for the export good and coal is used for domestic consumption?
  - Switching fuel sources has no effect on overall emissions.
  - And might be trivial to do.

Marginal source of energy

- Ideally, the tax should be based on the additional emissions because the exported good was produced.
- Estimate emissions on the assumption that the marginal source of energy had been used.
- Don’t use actual emissions!
  - Legal issues?
- How do we compute the marginal source of fuel?
- Based on country or regional estimate?

Production process

- Same good can be produced using wide variety of production processes.
- How do we determine the process used? Activity takes place abroad, so we may lack the necessary information.

- Suggestions:
  - Actual production process used.
  - Average method in the exporting nation.
  - Average method used in importing.
  - Best available technology.
  - Worst available technology (plus allow proof of better method).
  - Global average.

- Do this for each good or for broad categories?
- Adjust the estimates every __ years?

Which emissions?

- Direct – from actual production process.
- Indirect – from power, heat, or steam used in production, even if from third party.
- All

- Most studies suggest direct + indirect

From which countries?

- All
- Only countries without “comparable” carbon regulation.

All countries?

- No need to determine which countries are subject to border adjustments.
- But:
- Adds many countries – already complex BTA schedules become more so.
- If a country with a carbon price does not have BTA's, can lead to double tax on its exports.
  - Tax in F and border tax when sold in H.
  - Countries would have to coordinate BTAs. Not likely and not easy.
- "All" seems infeasible.

Countries without comparable carbon regimes

- Might greatly simplify system.

- Far fewer trade exposed goods, from fewer countries.

Imports of EITE goods

U.S. Imports by Origin, 2005

	Steel		Aluminum		Chemicals		Paper		Cement	
Rank	*Source*	*Share*	*Source*	*Share*	*Source*	*Share*	*Source*	*Share*	*Source*	*Share*
1	Canada	18.6	Canada	51.0	Trinidad	41.6	Canada	66.9	Canada	16.1
2	EU	17.3	Russia	17.1	Canada	19.3	EU	16.8	China	14.0
3	Mexico	13.1	EU	6.2	Ukraine	7.3	China	3.5	EU	13.9
4	Brazil	8.2	OPEC	5.1	OPEC	6.6	S. Korea	2.2	OPEC	10.0
5	China	7.1	Brazil	3.8	EU	4.5	Mexico	2.2	Thailand	8.6

Source: Houser et al 2008

But

- What is a comparable carbon regulation?
- Vast number of regulatory choices.
  - Types of command and control are effectively infinite.
- Even just within taxes and/or cap and trade systems, wide variation.
  - Rates, base, exemptions, upstream/downstream, BTA's, local v. national, offsetting subsidies, CDM's, etc.
  - Plus systems change all the time.
- Decision to impose BTA's from a country will be highly political.
  - No objective criteria.
  - Countries will contest decision.
  - Every time they change their system, have to make a new determination.

Transshipping

- If BTA's are imposed only from some countries, easy avoidance.

- Three countries:
  - H
  - F – no carbon price.
  - G – carbon price but no BTAs.

- Suppose H imposes BTA's on imports from F but not G.
  - F sells goods to G.
  - G sells similar (but not the same) goods to H.
  - Not just routing the goods through G.

Summary

Is this really worth it?

Look at simple model to understand welfare/trade effects.

A model of carbon leakage

Simplest possible model

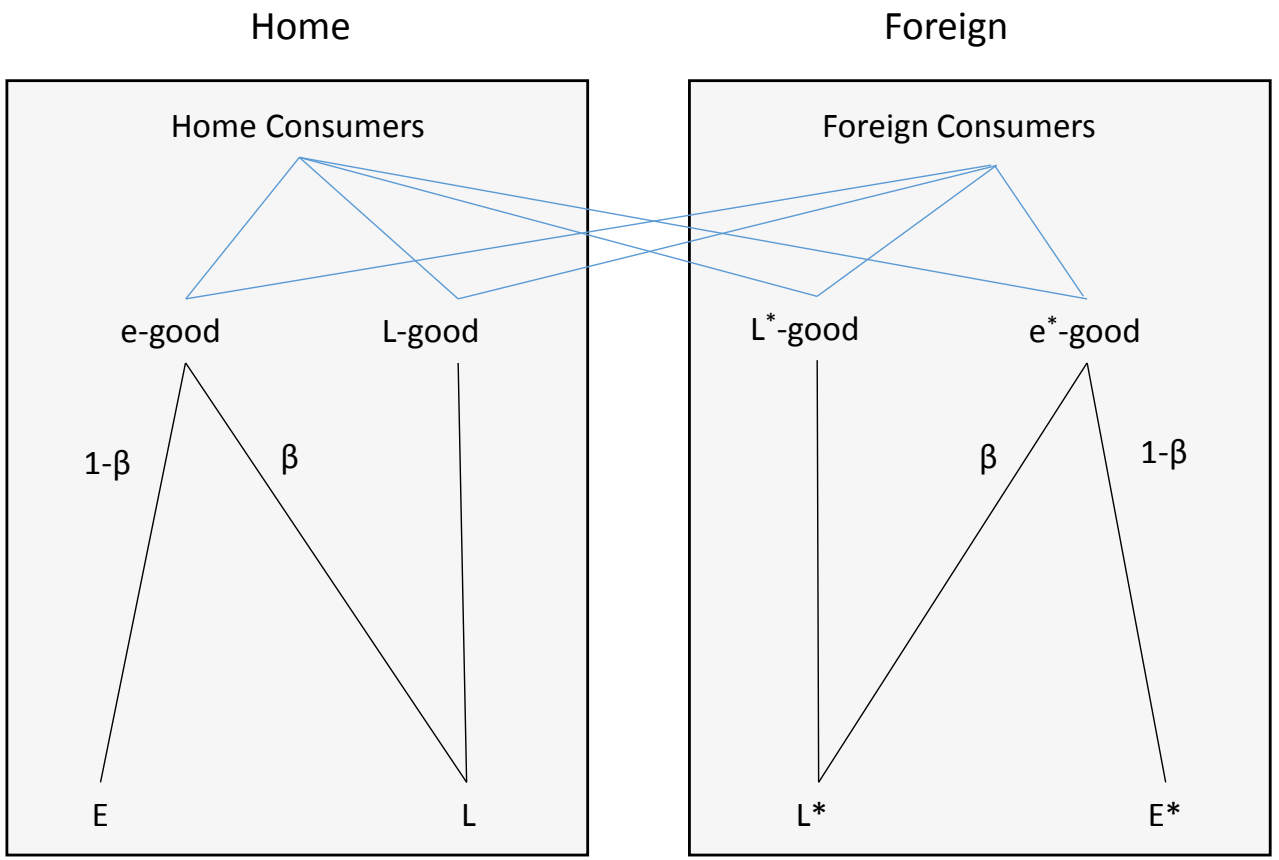
- Two countries/regions: H and F.
  - Each endowed with labor, L and L^*, and deposits, E and E^* (where * denotes F)
- Two goods:
  - L-good – services.
  - e-good – energy.
  - Both costlessly traded.

- e-good is produced using deposits and labor, with Cobb-Douglas production and labor share β, and elasticity of supply $\varepsilon=\beta/(1-\beta)$.
  - This can arise from heterogeneity in extraction costs of different deposits of energy. *E* can be thought of as a scale parameter for the distribution of deposits.

- L-good is produced using labor.

- CES preferences over the goods with elasticity of substitution σ.

Basic model


Home
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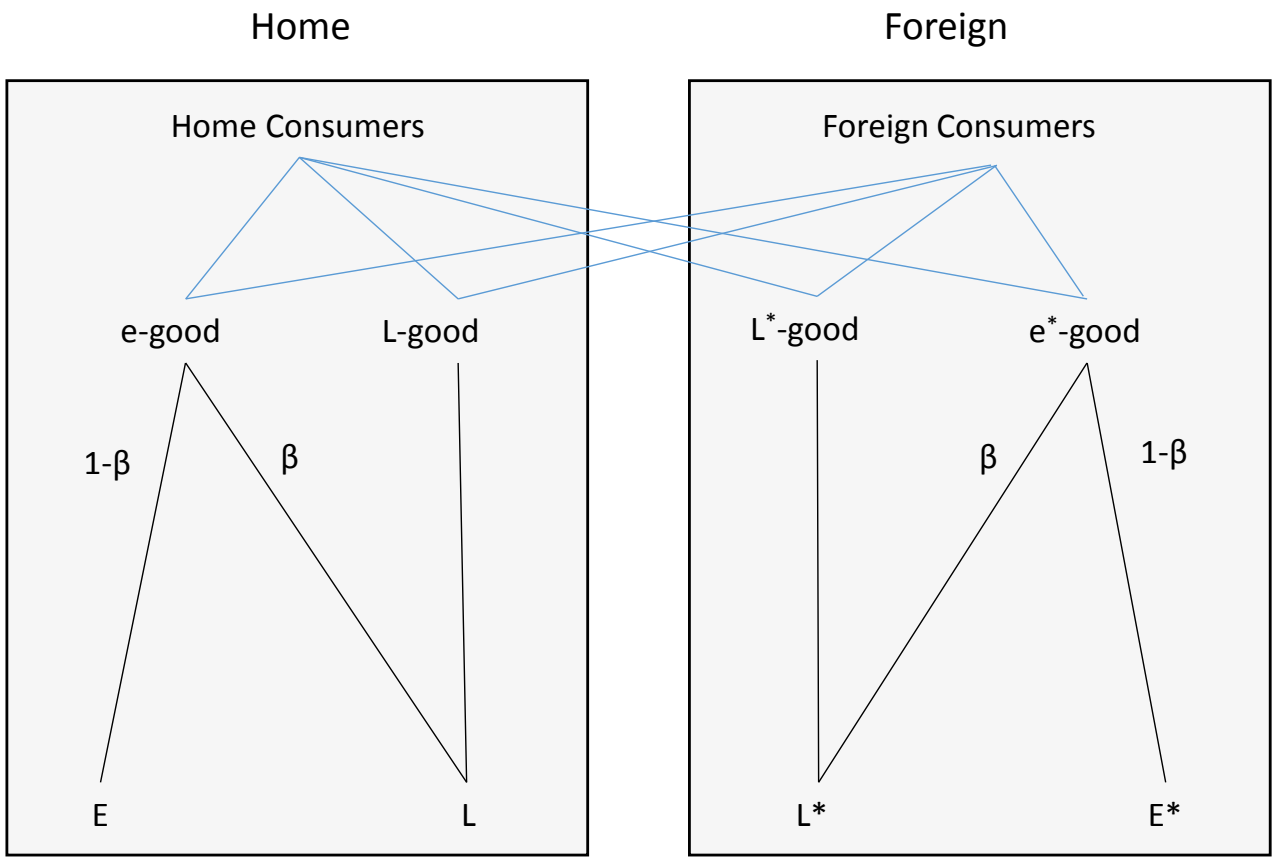
Taxes

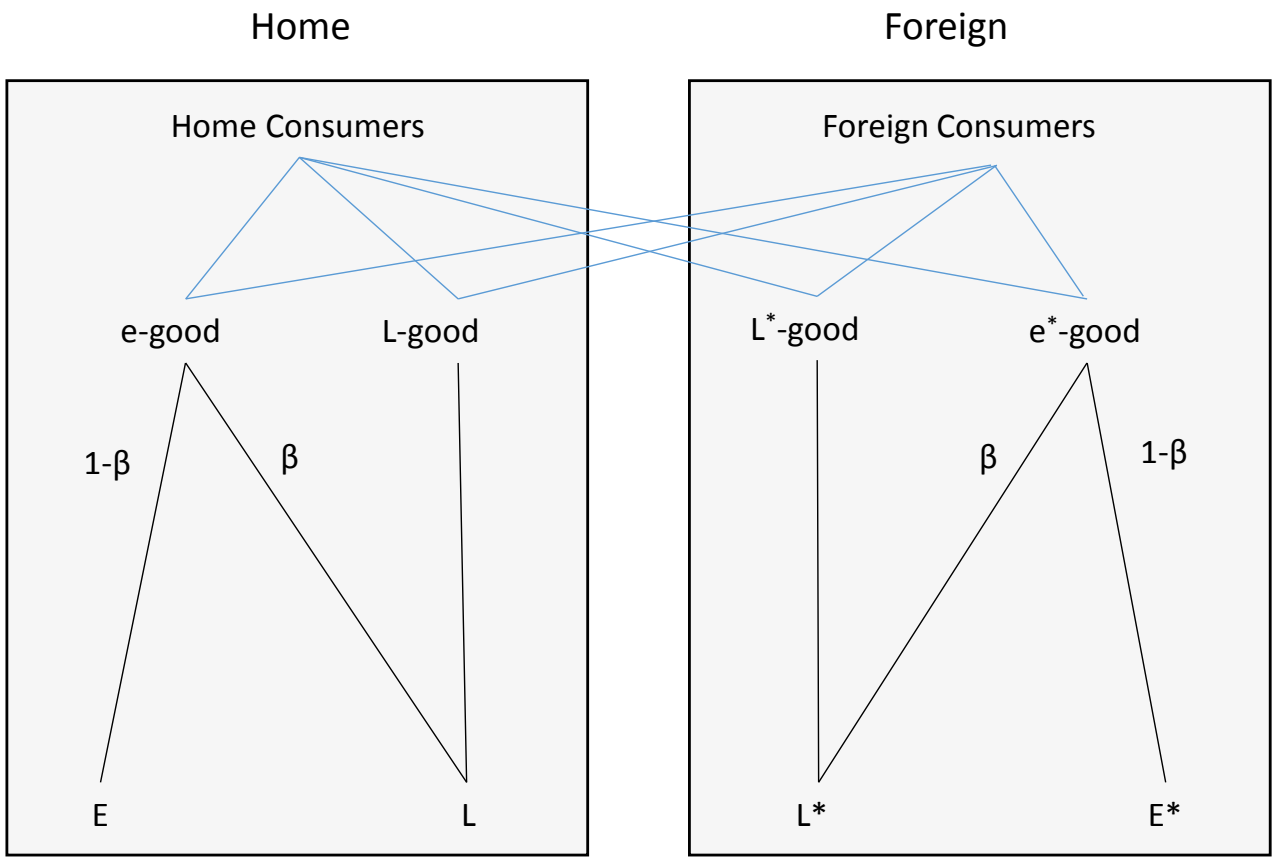
Extraction tax



Taxes

Consumption tax

Extraction tax



Basic results

- Global extraction tax and global consumption tax are identical if preferences in the two countries are the same.
  - But tax revenue shifts between the countries.

- If preferences are not the same, tax revenue differences can lead to consumption (and, therefore, production) differences even with a global tax.

- Extraction tax + border taxes = consumption tax.
  - Border taxes shift the tax downstream.

Effect of Tax in H on the Price of Energy

- Extraction tax:

Increases global price of energy.

Less global consumption of the e-good.

But increased extraction in F partially offsets.

- Consumption tax (production tax + border tax adjustments):

Reduces demand for the e-good in H.

Reduces the demand for, and price of, energy.

Less extraction in F but more consumption in F.

Two types of leakage

- Tax in H changes the global price of the e-good (by changing either production or consumption in H).
- This changes both production and consumption in F.

- Production leakage:

  Producers in F will change how much they produce.

- Consumption leakage:

  Consumers in F will change how much they consume.

Extent of leakage from extraction tax

- Elasticity of demand for energy:
  - If σ is high, tax cannot increase price of energy very much b/c consumers will substitute away.
  - As σ goes up:

    Smaller increase in F production.

    Smaller decline in F consumption.

    The tax mostly reduces rents to owners of deposits in H.

- Elasticity of energy supply:
  - High supply elasticity means small increases in price → big increases in supply in F.
  - Smaller declines in consumption in both H and F.
  - As ε goes up:

    Bigger increase in F production.

    Smaller decline in F consumption.

Extent of leakage from a consumption tax

- Elasticity of demand:
  - Price and supply of the e-good go down more if elasticity is higher
  - F producers produce less but F consumers buy more.
  - As σ goes up:

Bigger decline in F production.
Bigger increase in F consumption of the e-good.

- Elasticity of supply:
  - Tax reduces demand for the e-good.
  - As ε goes up:

Smaller decline in F production.
Smaller decline of F consumption.

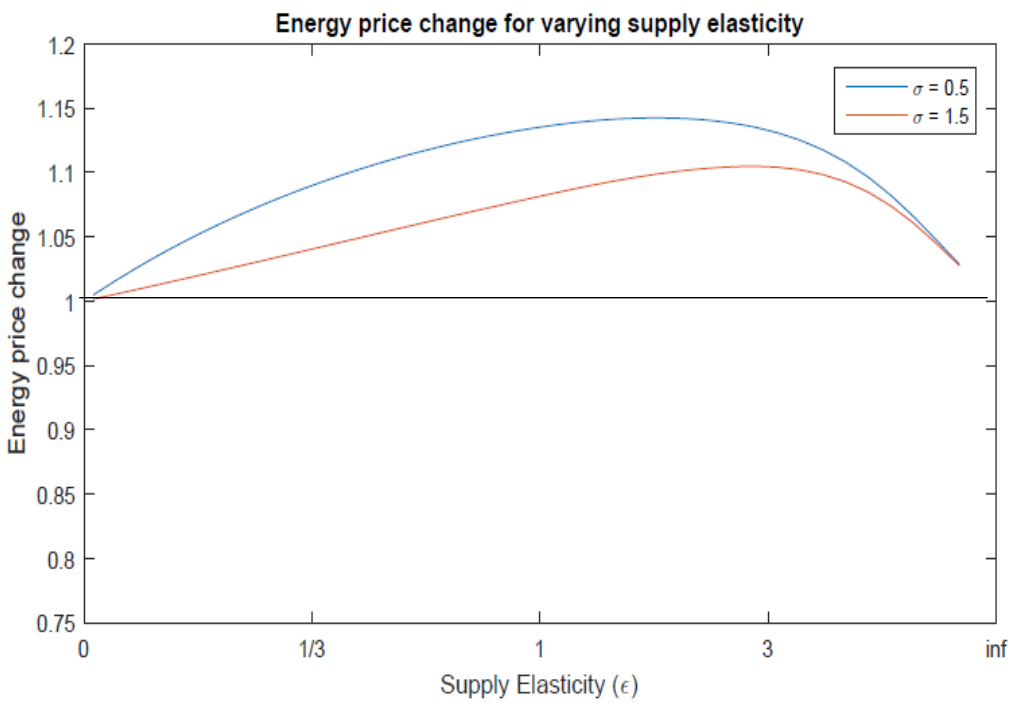
Simulations

- Rough numbers.
- Not yet calibrated.

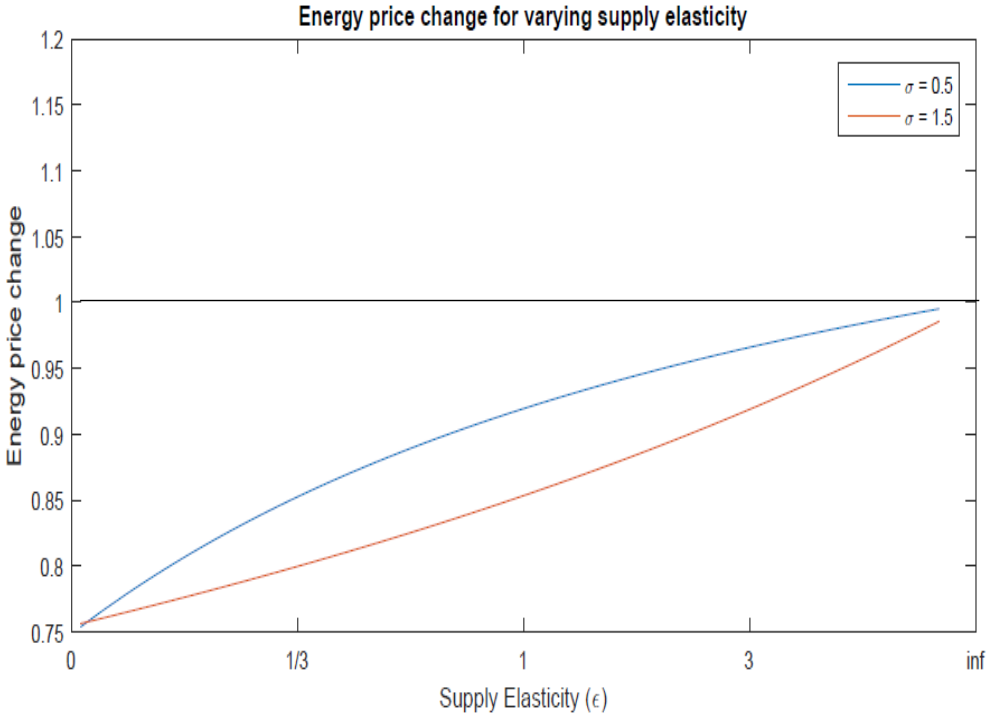
- Simulation strategy:
  - Hold pre-tax revenue of the energy sector as percent of GDP constant. Can base this on observations.
  - Estimate how other values change when we change parameters, such as the elasticities or tax rates.
  - Find equilibrium price of energy. Everything else follows.

Energy price

Extraction tax

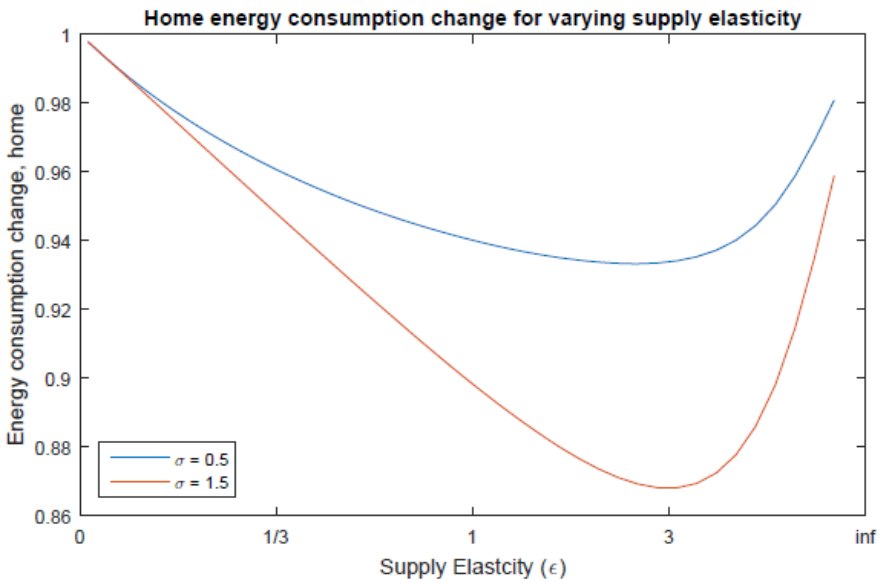


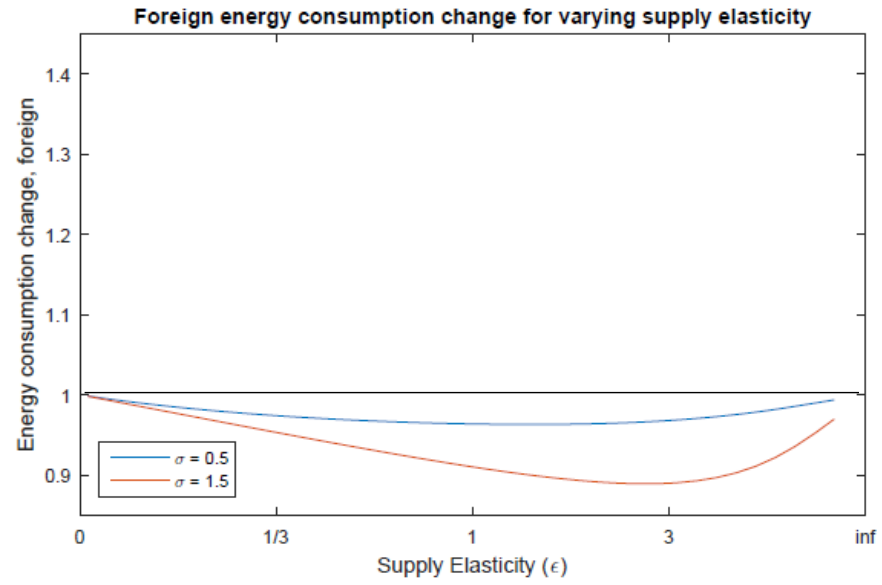
Consumption tax



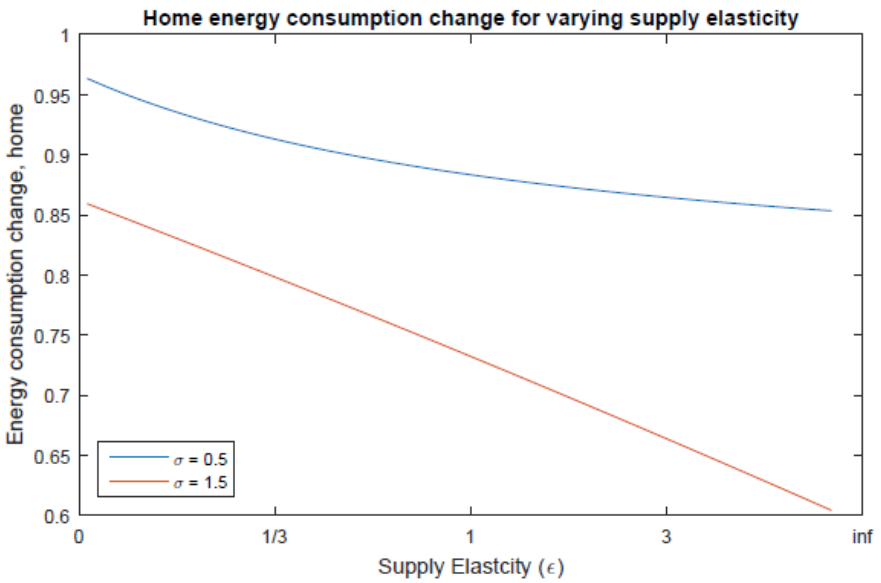
Energy consumption

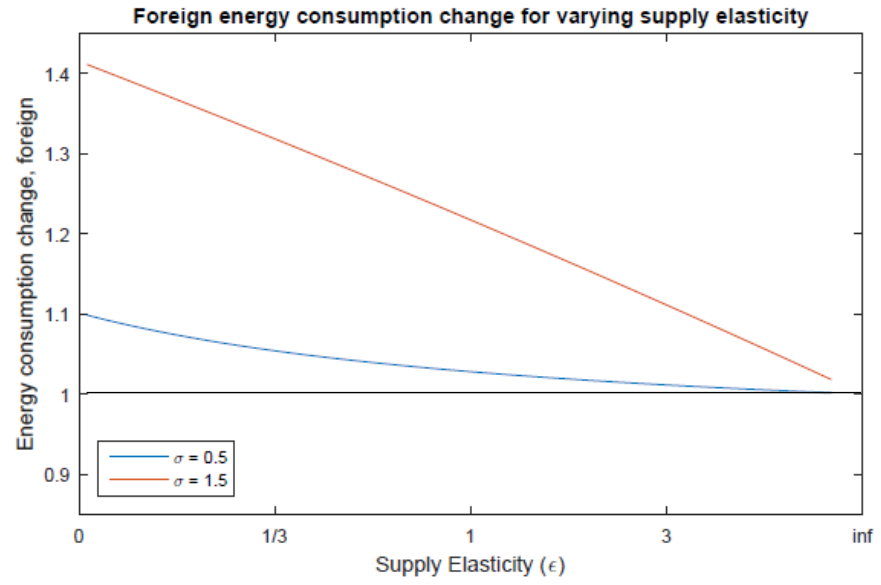
Extraction tax





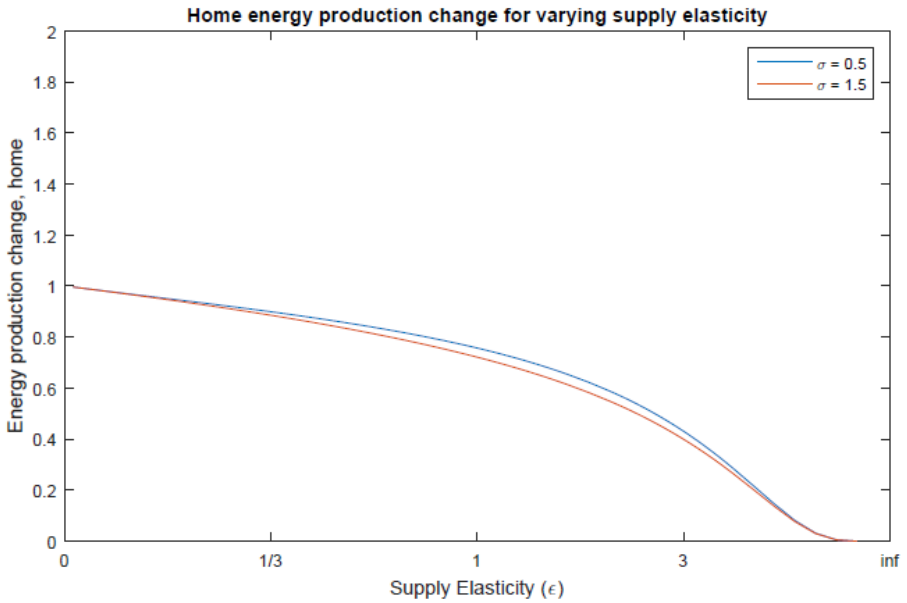
Consumption tax

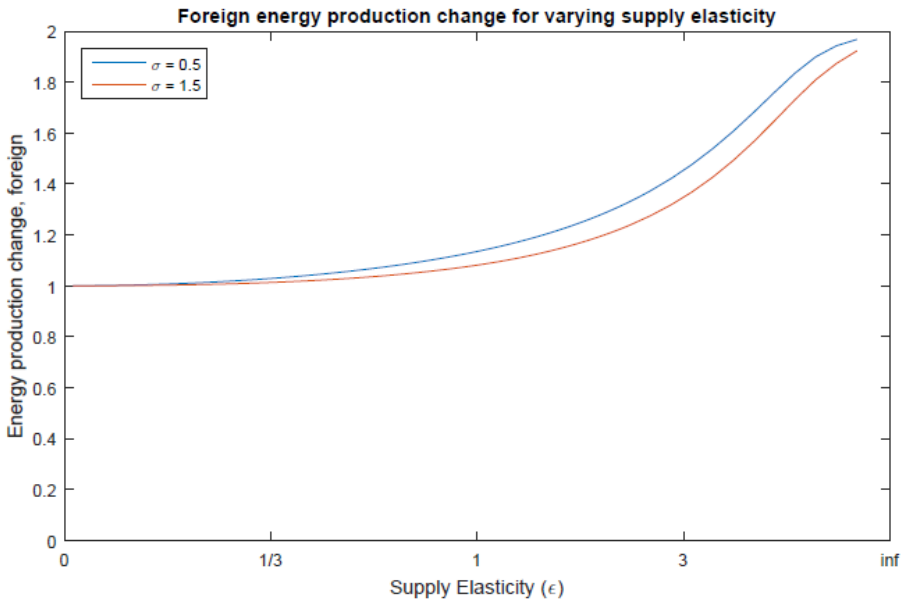




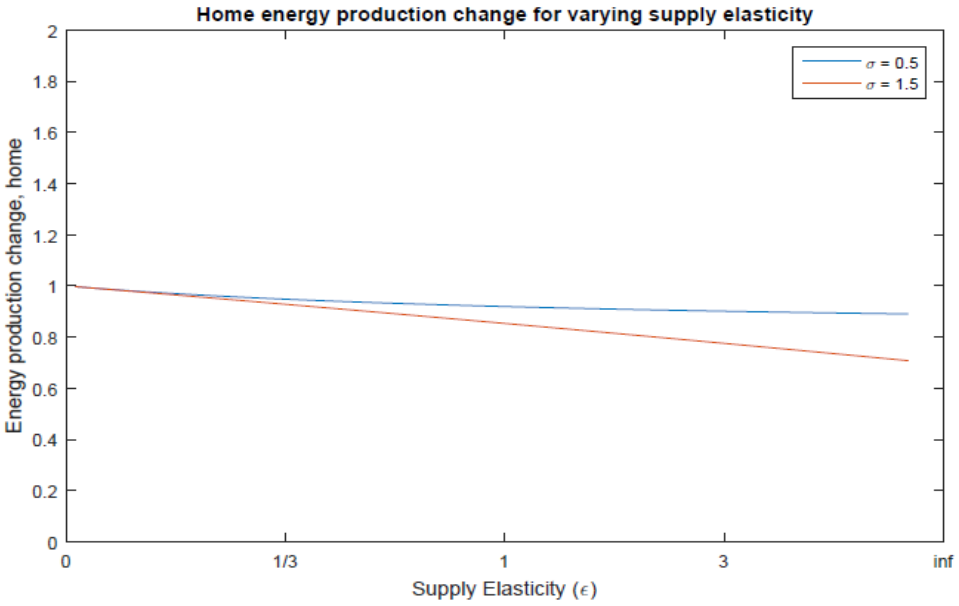
Energy production

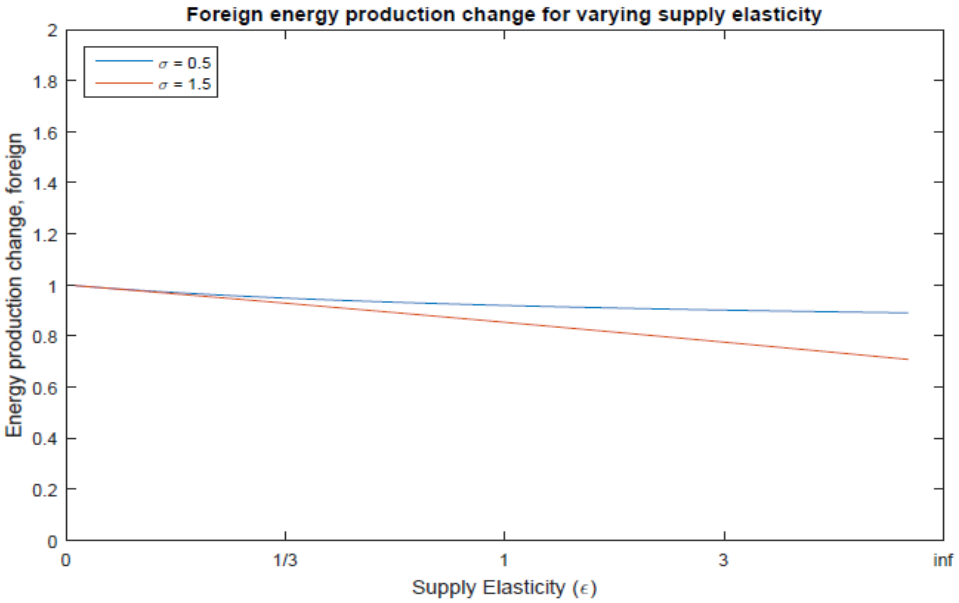
Extraction tax



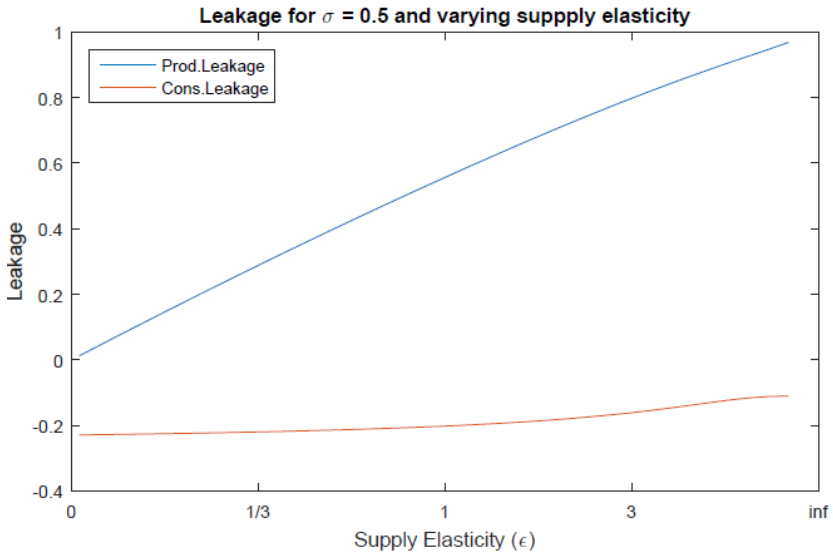


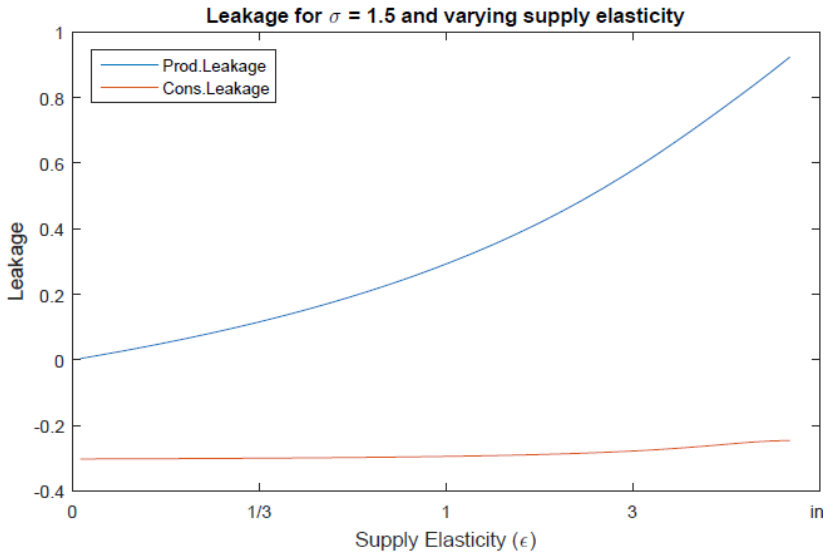
Consumption tax

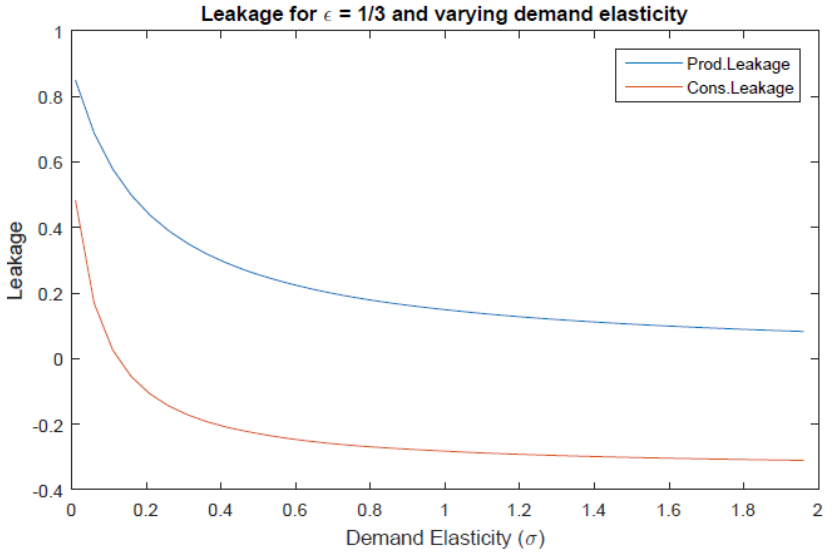


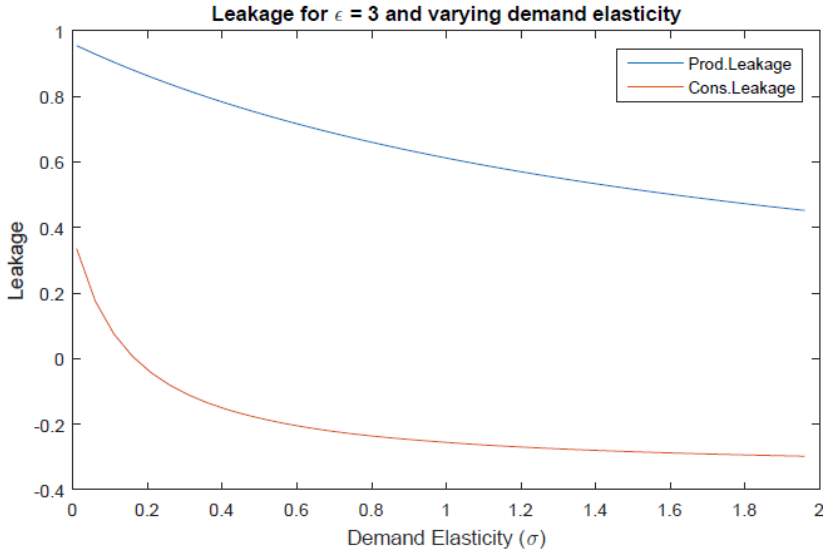


Leakage under an extraction tax

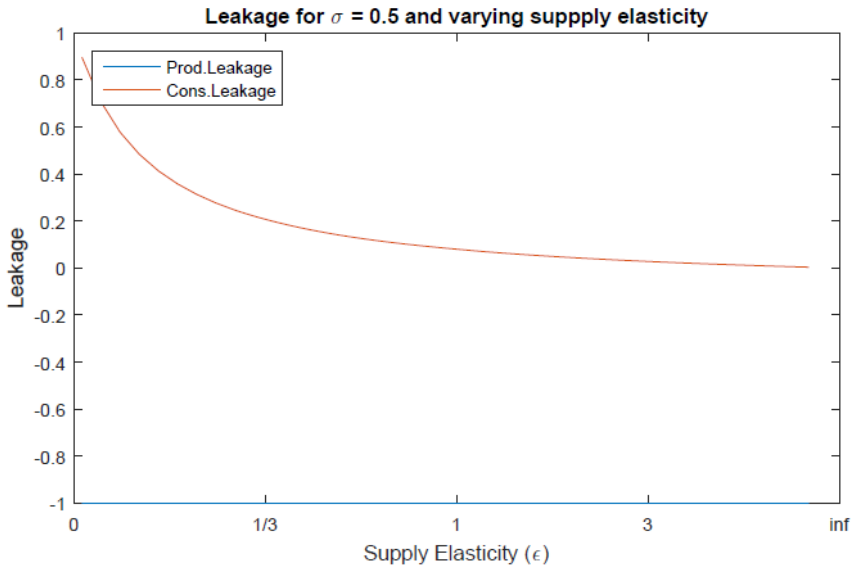


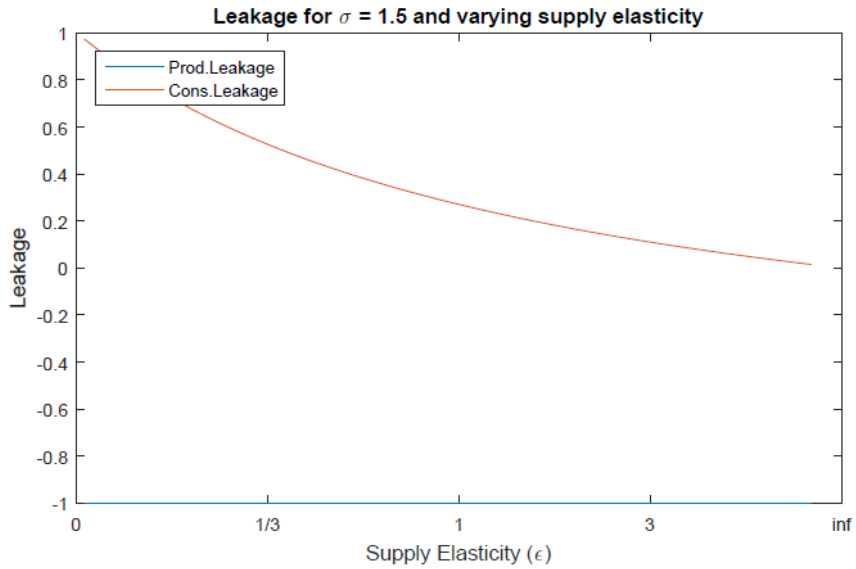


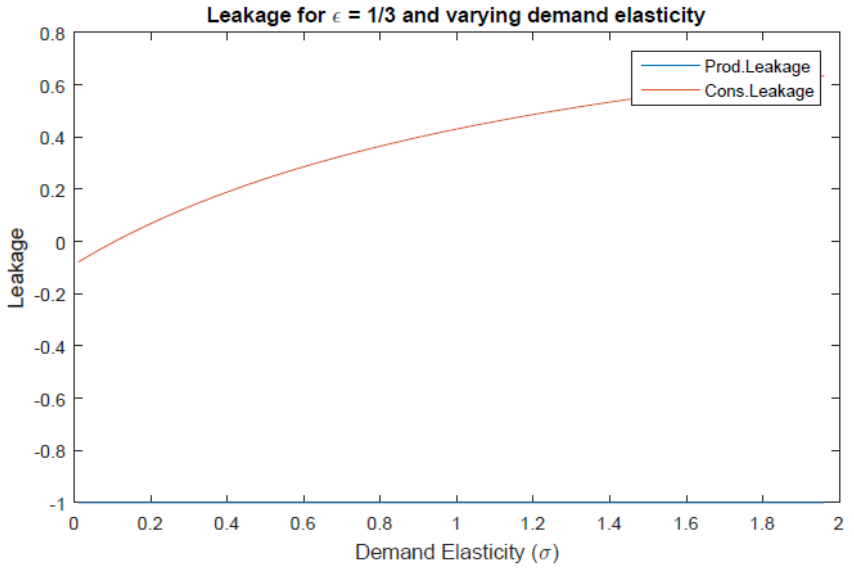


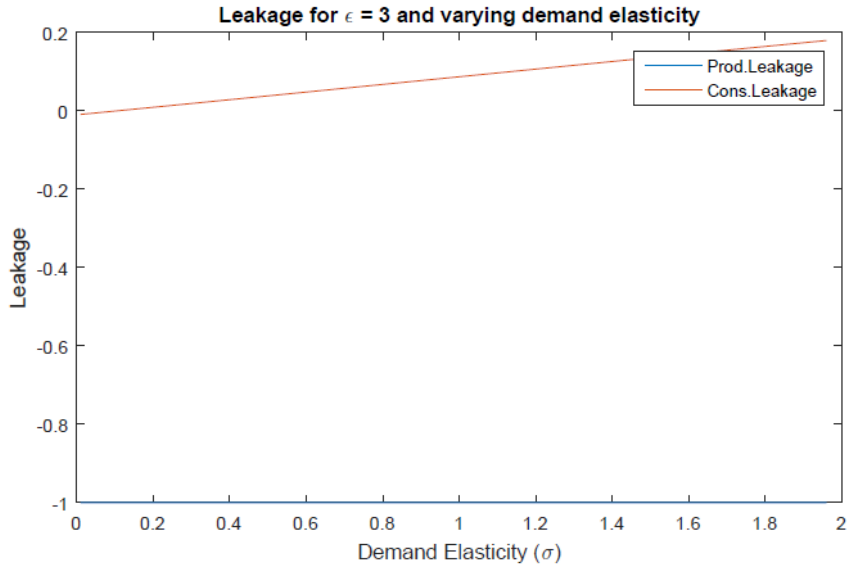


Leakage under a consumption tax









To do:

- Welfare calculations:
  - Find consumption/production tax combinations that hold emissions constant.
  - Calculate H and F welfare.

- Add a manufacturing sector.
  - Extraction of energy using labor.
  - Trade in energy.
  - Use energy in manufacturing with DFS-type structure, so specialization in particular goods in H and F.
  - Consumption of l-good, e-good, and m-good.
  - Consider extraction tax, production tax and consumption tax.

- Calibrate the simulation.

Conclusions

- Border adjustments are very difficult.
- Only real possibility is crude proxy for limited goods.
- Even then, serious administrative and political costs.

- Model:
  - To understand leakage, need to think about effects on price of energy.
  - This will affect F production and F consumption.
  - Two types of leakage, that may often work in opposite directions.
  - Elasticity of supply and demand for energy affect extent of leakage.