

Problem Set 5

Due Wednesday, May 20 at 5pm

Problem 1: True, false, or uncertain

Please *evaluate* whether each statement is true, false, or uncertain. Use economic reasoning, graphical analysis, or evidence discussed in class.

1. After the government imposes a 10% import tariff, the government budget will increase by an amount equal to 10% of the current value of imports.
2. It is better for social welfare to impose import tariffs on goods with inelastic demand, such as necessities, rather than on goods that are highly substitutable, such as consumer electronics.
3. A reduction in trade barriers between two countries leads to the expansion of existing firms in those countries.
4. Industries with higher marginal costs have fewer firms in the market because achieving an efficient scale of production is more difficult.

Problem 2: Did the 2018 washing-machine tariff pay for itself? (Flaaen, Hortaçsu and Tintelnot, 2020)

For this question, read [this UChicago News summary](#) of Flaaen, Hortaçsu and Tintelnot (2020), *The Production, Relocation, and Price Effects of US Trade Policy: The Case of Washing Machines*, *American Economic Review*. You do not need to read the paper itself to answer the questions.

In January 2018 the Trump administration imposed *Section 201 safeguard duties* on imported large residential washing machines, after a petition from Whirlpool. The remedy was a tariff-rate quota: 20% on the first 1.2 million imported washers per year, 50% above that. The within-quota allowance was binding by October 2018, so on the margin every additional imported washer faced the 50% rate; we will therefore model the safeguard as a *uniform* 50% ad valorem tariff. Flaaen et al. document that pass-through to retail washer prices was approximately complete — justifying the small-open-economy assumption — and estimate that the tariff cost US consumers about \$1.5 billion per year and created about 1,800 new manufacturing jobs ($\approx$ \$820,000 per job). This problem builds the textbook small-country tariff model, computes those welfare areas at a calibration matching the 2017 US washer market, and asks you to compare the model's predictions to Flaaen et al.'s empirical estimates.

Setup. Take the US washing-machine market as a small open economy. Let p denote the domestic price in dollars per washer and let quantities be measured in millions of units. Domestic demand and supply schedules:

$$D(p) = 20 - p/70, \quad S(p) = p/350.$$

The world price (the price at which the US can buy any quantity from foreign exporters under free trade) is $p^* = \$700$ per washer. The ad valorem tariff is $t = 0.50$, so the tariff-inclusive domestic price under the safeguard is $p_H = (1 + t)p^* = \$1,050$.

	Free trade ($p = p^*$)	Tariff ($p = p_H$)	Change
Domestic demand D (M units)	10	5	−5
Domestic supply S (M units)	2	3	+1
Imports $M = D - S$ (M units)	8	2	−6

1. **Free-trade benchmark.** Verify the entries in the “free trade” column of the table by evaluating $D(p^*)$ and $S(p^*)$. On a partial-equilibrium (Q, p) diagram, sketch the domestic supply and demand curves, draw the horizontal world-price line $p = p^*$, and label the free-trade quantities S^{FT} , D^{FT} and the import volume $M^{\text{FT}} = D^{\text{FT}} - S^{\text{FT}}$.
2. **The safeguard tariff.** Under the safeguard, foreign exporters must hand t of every dollar of declared value over to US customs, so they net only $p/(1 + t)$ of any price US consumers pay. In the lecture’s *Home market with $S_H + X_F$* frame, free trade gives a perfectly elastic foreign export supply X_F at the world price p^* . *Draw the new effective foreign export supply curve X_F^t facing US consumers under the safeguard*, and explain in one sentence why it lies at $p_H = (1 + t)p^* = 1050$. Then evaluate $D(p_H)$ and $S(p_H)$ to verify the “tariff” column of the table, mark the tariff-distorted quantities S^{T} , D^{T} on the diagram, and shade the four welfare regions a, b, c, d as defined in lecture. Verify that imports shrink from $M^{\text{FT}} = 8$ to $M^{\text{T}} = D^{\text{T}} - S^{\text{T}} = 2$ million.
3. **Welfare decomposition.** Compute the four welfare areas a, b, c, d in millions of dollars. Then sum to obtain the consumer-surplus loss ΔCS , the producer-surplus gain ΔPS , government tariff revenue G , and the net welfare change ΔW for the United States. Express each in billions of dollars and verify that $\Delta \text{CS} = a + b + c + d$ and $\Delta W = -(b + d)$.
4. **Large-country case: terms of trade and the Irwin sugar evidence.** Flaaen et al.’s finding that pass-through into US washer prices was approximately complete justifies treating the US as a small economy in the world washing-machine market: foreign export supply X_F is essentially flat and the entire \$350 tariff wedge is borne by US consumers. To see what changes when a country is large enough to move the world price, let us switch to a different historical case. In *Tariff Incidence: Evidence from US Sugar Duties, 1890–1930* (summarised in [the NBER Digest](#)), Douglas Irwin uses high-frequency data from a period when the United States consumed more than 20% of world sugar production. He finds that of the wedge introduced by a tariff *increase*, about 40% is passed on to US consumers as a higher domestic price and the remaining 60% is absorbed by foreign exporters as a lower export price.

Set up the lecture’s *Who absorbs the tariff?* partial-equilibrium Home-market diagram – Home demand D_H together with combined supply $S_H + X_F$ – for this large-country case, and show how a specific tariff t moves the equilibrium.

- 4.a. *Home band*. On the diagram, identify the vertical distance corresponding to the share of t borne by US consumers. Between which two horizontal price lines does it lie, and what is its economic meaning?
- 4.b. *Foreign band*. Identify the vertical distance corresponding to the share borne by foreign exporters, and again name the two horizontal price lines that bound it.
- 4.c. Under Irwin's 40/60 split, which of the two bands is *taller*? What does this imply about the relative elasticity of foreign export supply X_F and combined supply $S_H + X_F$ at the equilibrium?
- 4.d. *Did the sugar tariff improve American welfare*? Tie your answer to the role foreign-export-supply elasticity plays in driving the terms-of-trade transfer.
5. **Confronting the data**. Flaaen et al. (2020) report that the safeguard cost US consumers about \$1.5 billion per year and created roughly 1,800 new domestic manufacturing jobs.
 - 5.a. Compare your model's predicted Δ CS from part 3 to Flaaen et al.'s \$1.5 billion estimate. By what *factor* does the simple model over- or under-state the empirical loss?
 - 5.b. Using your model's ΔW (equivalently $-(b + d)$) and the paper's 1,800-jobs figure, compute the implied *deadweight loss per job created*. Compare this number to the headline statistic of \$820,000 in consumer cost per job, and discuss what each of the two measures is actually capturing.

Problem 3: The Canada–U.S. Auto Pact and the Krugman model (Fuss and Waverman, 1992)

For this question, read [Michael Hart's Policy Options retrospective on the Auto Pact](#) (alternatively, the Wikipedia entry on the [Canada–United States Automotive Products Agreement](#)). You do not need to read Fuss and Waverman (1992) itself to answer the questions.

On January 16, 1965, the United States and Canada signed the *Automotive Products Trade Agreement* – the **Auto Pact** – which eliminated tariffs on cars, trucks, and original-equipment parts moving between the two countries.¹ The agreement was conditional on the “Big Three” assemblers (General Motors, Ford, Chrysler) maintaining Canadian production at or above 1964 levels and, in side-letters, pledging to raise Canadian value added by at least 60% of the growth in their Canadian sales.² Before 1965, Canada had a small, tariff-sheltered auto sector: U.S.-owned branch plants built a wide range of models in short, expensive runs – Ford alone assembled 71 car and 227 truck models in Canada in 1964. After 1965, Canadian plants specialized in far fewer models built for the entire North American market: within three years Ford had cut its Canadian lineup to 49 car and 64 truck models, and GM halved the number of models it built in Canada.³ As the market

¹Signed at Johnson City, Texas, 16 January 1965: *Agreement Concerning Automotive Products*, Canada Treaty Series 1966 No. 14.

²On the 1964-level production safeguard and the side-letter pledge to add Canadian value equal to 60% of the growth in Canadian sales, see [Michael Hart, “The Auto Pact: Forerunner of Free Trade,” Policy Options, 2002](#).

³Ford's model reduction (71 to 49 cars, 227 to 64 trucks) is from Rodney W. Markley's 1968 congressional testimony; it and the GM figure are reported in [Dimitry Anastakis, *Auto Pact: Creating a Borderless North American Auto Industry, 1960–1971*, Univ. of Toronto Press, 2005](#).

integrated, U.S. imports of automotive products from Canada grew roughly *forty-fold* by value (and U.S. exports to Canada about *ten-fold*) between 1965 and 1977.⁴ The Helpman–Krugman (1985) reading of this episode is that selective market integration delivered the textbook gains from intra-industry trade: economies of scale, lower markups, and more varieties for consumers. Fuss and Waverman (1992) test this prediction with plant-level data on Canadian assembly and find that the Auto Pact reduced Canadian unit production cost by about 3.1% relative to a counterfactual without the agreement, and that Canada’s plant-scale disadvantage relative to U.S. plants shrank from 21.1% in 1962–64 to 12.1% in 1970–72. (Canada’s *overall* unit-cost disadvantage narrowed from 27% to 19% over the same window – an 8 percentage point gain, of which they credit only about a third, roughly 3 points, to the Auto Pact itself.)⁵ This problem builds the symmetric Krugman model, computes its predictions for the Canada–U.S. integration, and asks you to compare them to Fuss and Waverman’s empirical estimates.

Setup. Two countries – Canada (Can) and the United States (US) – produce differentiated cars under monopolistic competition. Each firm sells one variety; demand for variety i in a market of size S when consumers face n competing varieties at average price $\bar{P}$ is the lecture’s linear-demand form

$$Q_i = S \left[1/n - b(P_i - \bar{P}) \right].$$

Every firm faces marginal cost c and fixed cost F , and there is free entry. In a symmetric equilibrium, the pricing rule and zero-profit conditions are

$$P = c + 1/(bn) \quad (\text{PP}), \quad P = c + Fn/S \quad (\text{CC}).$$

Combining PP = CC and solving for n ,

$$n^* = \sqrt{S/(bF)}, \quad Q^* = \sqrt{bFS}, \quad P^* = c + \sqrt{F/(bS)}, \quad \text{markup}^* = \sqrt{F/(bS)}.$$

Calibration. $c = 1$ (k\$ per car, normalized), $b = 1$ (1/k\$), $F = 0.5$ (k\$ per firm, fixed). Auto-market sizes (millions of vehicles per year, scaled): $S^{\text{Can}} = 1$ and $S^{\text{US}} = 4$. Under free trade with no iceberg cost ($\tau = 1$) the relevant market for every firm is the *integrated* North American market $S_W = S^{\text{Can}} + S^{\text{US}} = 5$.

	Canada (autarky)	US (autarky)	Integrated ($S_W = 5$)
Varieties n^*	$\sqrt{2} \approx 1.41$	$\sqrt{8} \approx 2.83$	$\sqrt{10} \approx 3.16$
Plant scale Q^*	$\sqrt{0.5} \approx 0.71$	$\sqrt{2} \approx 1.41$	$\sqrt{2.5} \approx 1.58$
Price P^*	$1 + \sqrt{0.5} \approx 1.71$	$1 + \sqrt{0.125} \approx 1.35$	$1 + \sqrt{0.1} \approx 1.32$
Markup $P^* - c$	$\sqrt{0.5} \approx 0.71$	$\sqrt{0.125} \approx 0.35$	$\sqrt{0.1} \approx 0.32$

⁴Jack L. Hervey, “Canadian–U.S. auto pact 13 years after,” *Economic Perspectives*, Federal Reserve Bank of Chicago, July/Aug. 1978: by 1977 U.S. imports from Canada reached 9.1 billion dollars (about fortyfold the 1965 level) and exports to Canada 8.4 billion dollars (about tenfold).

⁵Melvyn Fuss and Leonard Waverman, “The Canada–U.S. Auto Pact of 1965: An Experiment in Selective Trade Liberalization,” NBER Working Paper No. 1953, 1986, published as a chapter in *Costs and Productivity in Automobile Production*, Cambridge Univ. Press, 1992 (pp. 172–208).

1. **Autarky equilibrium.** Verify the autarky columns of the calibration table by plugging $(c, b, F) = (1, 1, 0.5)$ and each country's S into the equilibrium formulas above. Then, in one sentence each: (i) which country has *more varieties* available to consumers in autarky? (ii) which country has *larger plants*? (iii) which country has *higher prices* and *higher markups*?
2. **Free-trade integrated-market equilibrium.** With $\tau = 1$, both Canadian and U.S. consumers buy from every firm in the integrated North American market of size $S_W = S^{\text{Can}} + S^{\text{US}} = 5$, and every firm sells to every consumer. Compute (n_W^*, Q_W^*, P_W^*) and verify the integrated column. Build a PP-CC diagram that shows how the Auto Pact moves Canada and the United States from their autarky equilibria to the integrated-market equilibrium.
3. **Decomposing the gains from trade.** Opening to trade raises each consumer's welfare through two channels: the *variety* channel (more varieties on the shelf) and the *pro-competitive* channel (lower markups, lower prices).
 - 3.a. *Variety gain.* Compute the percentage change in the number of varieties available to a representative Canadian consumer ($n_{\text{Can}}^* \rightarrow n_W^*$) and to a representative U.S. consumer ($n_{\text{US}}^* \rightarrow n_W^*$).
 - 3.b. *Pro-competitive gain.* Compute the percentage change in the markup $P^* - c$ for each country.
 - 3.c. *Sources of gains on the diagram.* Return to the PP-CC diagram you built in part 2. Identify and label the two sources of gains from trade for Canada as Canada moves from E_{Can} to E_W along the PP curve. Which graphical distance corresponds to the love-of-variety gain, and which corresponds to the pro-competitive gain?
 - 3.d. *Smaller-country gains-from-trade prediction.* In both the Ricardian and the Heckscher-Ohlin models, we found that the *smaller* of the two trading partners typically gains more from trade. Does this prediction survive in the Krugman setup? Use your numerical answers from parts 3.a and 3.b to justify.
4. **Home market effect.** Now suppose that shipping a car across the border is costly: each unit shipped “melts” by a fraction so that a foreign customer effectively pays τ times the producer's price, with $\tau > 1$. The lecture's *home market effect* (Helpman-Krugman 1985) states that the country with the *larger* market hosts a *disproportionately* larger share of firms – and is a *net exporter* of the differentiated good.
 - 4.a. Under the calibration, what fraction of integrated-market demand does the United States represent? Under HME, what is the *minimum* predicted U.S. share of North American auto firms?
 - 4.b. In 1965 the United States assembled about 93% of all motor vehicles produced in North America; by 1970 the U.S. share was $\approx 89\%$.⁶ Are these shares consistent with the HME prediction?
5. **Confronting the data.** Compare the model's predictions in parts 2 and 3 to Fuss and Waverman's (1992) empirical findings for the Auto Pact.

⁶U.S. shares are the complement of Canada's share of two-country passenger-car output – 6.7% in 1964 rising to 11% by 1970 – in [Hervey \(1978\)](#).

- 5.a. *Intra-industry trade*. After 1965, U.S.–Canada auto trade is overwhelmingly *two-way*: each country exports *and* imports cars to/from the other in similar volumes, and the Grubel–Lloyd index $GL = 1 - |X - M|/(X + M)$ sits close to 1 throughout the post-Auto-Pact era. Is this pattern consistent with what the Krugman model predicts about trade between two similar economies, and how does it differ from what the Ricardian or Heckscher–Ohlin models would predict?
- 5.b. *Plant scale and average cost*. In a zero-profit equilibrium, the price P^* equals average cost. Compute the predicted percentage change in Canadian average cost on opening to trade. By what *factor* does the simple model over-state Fuss and Waverman’s estimated -3.1% Auto Pact cost reduction?
- 5.c. *One reason for the overstatement*. In one or two sentences, name a reason the simple Krugman model overstates the magnitude of the gains. (Hint: the lecture’s “Where does the simple Krugman model fall short?” slide is the right place to look.)