Together at Last: Trade Costs, Demand Structure, and Welfare

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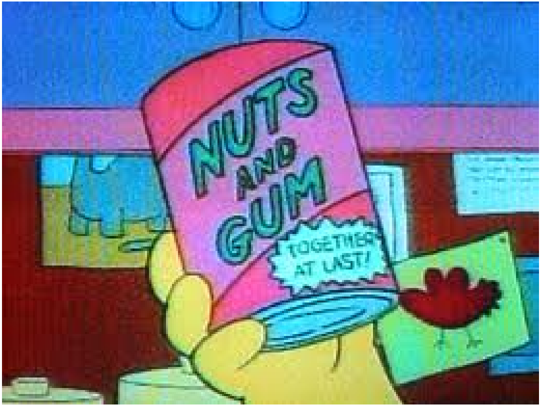
The Bottom Line



Trade Costs and General Demands: Together at Last!

Motivation

"Traditional trade theory assumes that countries are different and explains why some countries export agricultural products whereas others export industrial goods. The new theory clarifies why worldwide trade is in fact dominated by countries which not only have similar conditions, but also trade in similar products ... **This kind of trade enables specialization and large-scale production, which result in lower prices and a greater diversity of commodities.**"

Press Release for Paul Krugman's Nobel Prize (Emphasis added)

http://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/2008/press.html

Note: 3 of the 4 highlighted effects do not hold with CES preferences!

"This is an unsatisfactory result. In another paper [1979] I have developed a slightly different model in which trade leads to an increase in scale of production as well as an increase in diversity. That model is, however, more difficult to work with, so that **it seems worth sacrificing some realism to gain tractability** here."

Krugman (1980)

Our Contribution

- Search for tractability without sacrificing realism
- Combine trade costs and additive separability in a simple model
- Highlight the importance of demand properties, esp. "subconvexity"
- Focus on information needed to calibrate gains from trade

Background: Monopolistic Competition in GE

- Closed economy; additively separable preferences; CES as a special case:
  - Dixit-Stiglitz (1977)
- Trade costs with CES preferences:
  - Krugman (1980) etc.
- Trade costs and gains from trade with CES preferences:
  - Arkolakis-Costinot-Rodríguez-Clare (*AER* 2012), Simonovska-Waugh (2012), Melitz-Redding (2013), Ossa (2013)
- Free trade with additively separable preferences:
  - Krugman (1979)
  - Neary (2009), Zhelobodko-Kokovin-Parenti-Thisse (2012), Dhingra-Morrow (2012), Mrázová-Neary (2013)
- Trade costs with non-CES preferences:
  - Bertoletti-Epifani (2012)
  - Arkolakis-Costinot-Donaldson-Rodríguez-Clare (mimeo. 2012)
  - Bykadorov-Kokovin (2012)

Outline

Outline

Equilibrium in the Global Economy

- $\kappa + 1$ identical countries; n homogeneous firms in each
- Symmetric iceberg trade costs τ; no fixed costs of trade
- L identical worker-consumers per country, additively separable preferences:

$$U = F\left[\int_{i \in \mathcal{N}} u\{x(i)\} di\right], \; F' > 0, \; u' > 0, \; u'' < 0$$

- With symmetry: $x(i) = x$, $x^*(i) = x^*$

$$U = F\left[n\{u(x) + \kappa u(x^*)\}\right]$$

- Market clearing:

Goods-Market Equilibrium: $y = L(x + \kappa \tau x^*)$

Labor-Market Equilibrium: $L = n\left(f + cy\right)$

Superconvex Demands and Superconcave Utility

- Perceived demand function:
$$p = p(x) \qquad p' < 0$$
- Elasticity: $\varepsilon(x) \equiv -\frac{p(x)}{xp'(x)}$
  - FOC: $\varepsilon \geq 1$
- Convexity: $\rho(x) \equiv -\frac{xp''(x)}{p'(x)}$
  - SOC: $\rho < 2$
- CES: $p(x) = \beta x^{-\frac{1}{\sigma}}$
  - $\varepsilon = \sigma, \;\; \rho = \frac{\sigma+1}{\sigma} > 1$
- Superconvexity:
  - $p(x)$ more convex than CES
  - $\rho > \frac{\varepsilon+1}{\varepsilon}$
  - ε increasing in sales: $\varepsilon_x \geq 0$.

- Sub-utility function:
$$u = u(x) \quad u' > 0, \, u'' < 0$$
- Elasticity: $\xi(x) \equiv \frac{xu'(x)}{u(x)}$
  - Taste for variety: $0 < \xi < 1$
- CES: $u(x) = \frac{\sigma}{\sigma-1}\beta x^{\frac{\sigma-1}{\sigma}}$
  - $\xi = \frac{\sigma-1}{\sigma}$
- Superconcavity:
  - $u(x)$ more concave than CES
  - $\xi > \frac{\varepsilon-1}{\varepsilon}$
  - ξ decreasing in sales: $\xi_x \leq 0$.

Application

Outline

Integrated versus Segmented Markets

- Integrated: Prices equalized allowing for transport costs:

$$p^* = \tau p$$

- Segmented: *Marginal revenues* equalized allowing for transport costs:

$$r_x = c,\ r_x^* = \tau c \quad \Rightarrow \quad r_x^* = \tau r_x$$

- These are the same if and only if preferences are CES: ▸ Proof

$$r_x = \frac{\varepsilon - 1}{\varepsilon} p, \qquad r_x^* = \frac{\varepsilon^* - 1}{\varepsilon^*} p^*$$

- Segmented markets and subconvex demands imply *Reciprocal Dumping*:
  - Lower price-cost margins abroad: $\frac{p^*}{\tau c} < \frac{p}{c}$
  - Lower τ-inclusive prices abroad: $p^* < \tau p$

▸ Proof

Outline

Profit Maximization

- Assume segmented markets
- Profit maximization:

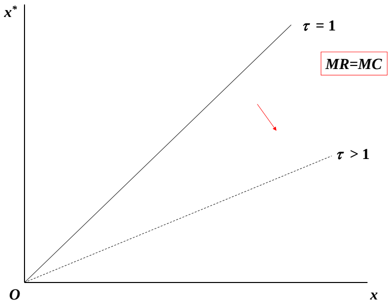
$$r_x^* = \tau r_x$$

$$\Rightarrow \quad \eta \hat{x} = \eta^* \hat{x}^* + \hat{\tau}$$

  - Elasticity of marginal revenue:

$$\eta \equiv -\frac{x r_{xx}}{r_x} = \frac{2-\rho}{\varepsilon - 1} > 0$$

- x^* *positively* related to x:
  - *Decreasing* in τ;
  - Independent of κ



CES: $\eta = \eta^* = \frac{1}{\sigma}$; $x^* = \tau^{-\sigma} x$

Free Entry

- Zero profits:

$$\pi + \kappa\pi^* = f$$

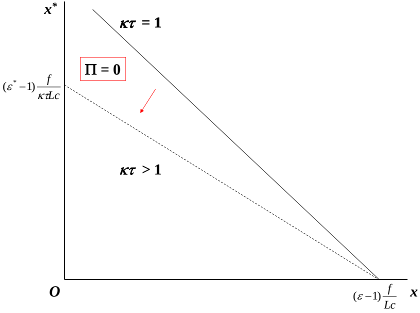
  - $\pi = (p - c)Lx = \frac{cLx}{\varepsilon - 1}$
  - $\pi^* = (p^* - \tau c)Lx^* = \frac{\tau cLx^*}{\varepsilon^* - 1}$

$$\Rightarrow \quad \frac{x}{\varepsilon - 1} + \kappa\tau\frac{x^*}{\varepsilon^* - 1} = \frac{f}{cL}$$

$$\Rightarrow \quad \omega_\pi \varepsilon\eta\hat{x} + (1 - \omega_\pi)\,\varepsilon^*\eta^*\hat{x}^* = -(1 - \omega_\pi)\,(\hat{\kappa} + \hat{\tau})$$

  - ω_π: Home market profit share

- x^* *negatively* related to x:
  - *Decreasing* in τ *and* κ



CES: $x + \kappa\tau x^* = (\sigma - 1)\frac{f}{cL} = \frac{y}{L}$

Equilibrium Sales

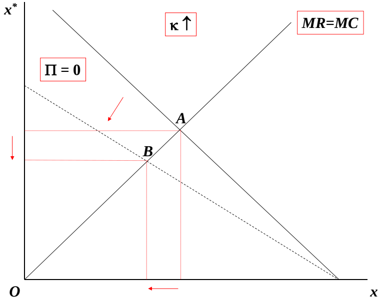
- Home and export sales:

$$\bar{\varepsilon}_\pi \eta \hat{x} = (1-\omega_\pi)\left[-\hat{\kappa} + (\varepsilon^* - 1)\hat{\tau}\right]$$

$$\bar{\varepsilon}_\pi \eta^* \hat{x}^* = -(1-\omega_\pi)\hat{\kappa} - \left[1 + \omega_\pi(\varepsilon - 1)\right]\hat{\tau}$$

  - π-weighted aggregate elasticity:

$$\bar{\varepsilon}_\pi \equiv \omega_\pi \varepsilon + (1-\omega_\pi)\varepsilon^*$$



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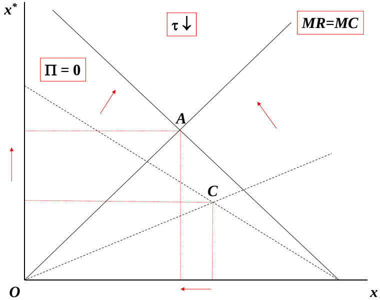

- Globalization ($\kappa \uparrow$): $x \downarrow \quad x^* \downarrow$
- Lower τ: $x \downarrow \quad x^* \uparrow$

CES: $\bar{\varepsilon} = \sigma$, $\bar{\varepsilon}\eta = \bar{\varepsilon}\eta^* = 1$

Implications for Prices, Output, and Firm Numbers

- Prices: $p = \frac{\varepsilon}{\varepsilon-1}c,\ \ p^* = \frac{\varepsilon^*}{\varepsilon^*-1}\tau c \quad \Rightarrow \quad \hat{p} = \frac{\varepsilon+1-\varepsilon\rho}{\varepsilon(\varepsilon-1)}\hat{x},\ \ \hat{p}^* = \frac{\varepsilon^*+1-\varepsilon^*\rho^*}{\varepsilon^*(\varepsilon^*-1)}\hat{x}^* + \hat{\tau}$
  - Both increasing with sales if and only if demands are subconvex
- Intensive margin: $y = x + \kappa\tau x^* \quad \Rightarrow \quad \hat{y} = \omega_x\hat{x} + (1-\omega_x)(\hat{\kappa} + \hat{\tau} + \hat{x}^*)$
  - ω_x: Share of home sales in total output
  - In free trade:
$$\hat{y}\Big|_{\tau=1} = (1-\omega)\left(1 - \frac{1}{\varepsilon\eta}\right)(\hat{\kappa}+\hat{\tau})$$
    - Positive if and only if $\eta > \frac{1}{\varepsilon}$ ...
    - ...i.e., if and only if demand is subconvex: $\eta - \frac{1}{\varepsilon} = \frac{\varepsilon+1-\varepsilon\rho}{\varepsilon(\varepsilon-1)}$
  - So: "Trade liberalization" ambiguous
    - Lower τ *reduces* firm output if and only if demand is subconvex.
- Extensive margin: $L = n(f + cy) \quad \Rightarrow \quad \hat{n} = -\psi\hat{y}$ Application
  - $\psi \equiv \frac{cy}{f+cy}$: Share of variable costs in total costs
    - Inverse measure of returns to scale; $\psi = \frac{\overline{\varepsilon}_h-1}{\overline{\varepsilon}_h}$
    - $\overline{\varepsilon}_h$: A sales-weighted harmonic mean of ε and ε^* Details

Outline

Welfare Change and the Elasticity of Utility

- Measure welfare change by the change in equivalent income, Y: ▸ Details

$$\hat{Y} = \left(\frac{\bar{\varepsilon}_z}{\bar{\varepsilon}_u} \frac{1}{\bar{\bar{\xi}}_u} - 1 \right) \hat{N}_Y - \omega_Y \hat{p} - (1 - \omega_Y) \hat{p}^*$$

  - $\xi \equiv \frac{xu'}{u}$: Elasticity of utility ▸ Recall properties

- Near free trade:

$$\hat{Y} \Big|_{\tau=1} = (1 - \omega) \left(\frac{1 - \xi}{\xi} \hat{\kappa} - \hat{\tau} \right) + \frac{\psi - \xi}{\psi \xi} \hat{n}$$

- Direct effect: Always welfare-improving
- Indirect effect: Sufficient conditions for a net gain:
  - $\psi = \xi$:
    - CES preferences guarantee efficiency: $\psi = \frac{\sigma - 1}{\sigma} = \xi$; *or*
    - Activist anti-trust policy adjusts n to ensure efficiency.
  - $\psi - \xi$ and $\hat{n}$ have the same sign; e.g.:
    - Utility is subconcave: $\psi > \xi$, varieties are under-supplied; *and*
    - Demand is subconvex: $\tau \downarrow \rightarrow\ y \downarrow \rightarrow\ n \uparrow$. ▸ Recall

Outline

Calibrating Gains from Trade

- ACRC: 2 sufficient statistics: $\begin{cases} \text{home market share} \\ \text{elasticity of import demand} \end{cases}$
- Calibrating home market shares:
  - $\omega_x = \omega_\pi = \omega_u$ *either* in free trade *or* with CES preferences
  - But not in general

Details

- Calibrating demand elasticities:
  - Calibrated elasticities frequently taken from import demand studies
    - Broda-Weinstein (2006): Median elasticity of 2.9
  - Recall: $\bar{\varepsilon}_i \equiv \omega_i \varepsilon + (1 - \omega_i) \varepsilon^* \quad i = x, z, \pi, Y, u$
  - With subconvexity and $x^* < x$:
    - $\varepsilon^* > \varepsilon \quad \Rightarrow \quad \varepsilon^*$ an upward-biased estimate of $\bar{\varepsilon}_i$ ...
    - ...which *underestimates* the gains from trade

Outline

Summary

- Integrated versus segmented markets:
  - Different except in CES case
  - Segmented markets and subconvexity imply reciprocal dumping
- Globalization versus colder icebergs:
  - Globalization reduces spending on all existing varieties
  - Lower trade costs switch spending from home to imported varieties
  - Isomorphic only in CES case
- Calibrating gains from trade:
  - Many more parameters need to be calibrated than in CES case
  - Home market shares in output, profits, and welfare differ in general
  - Import demand elasticities likely to be upward-biased estimates

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Proofs

- Marginal revenue and price:

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$$r(x) \equiv xp(x) \quad \Rightarrow \quad r_x = p + xp' = \left(1 + \frac{xp'}{p}\right) p = \frac{\varepsilon - 1}{\varepsilon} p$$

- Proof that mark-ups rise with sales if and only if demands are subconvex:

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$$\frac{p}{c} = \frac{p}{r_x} = \frac{\varepsilon(x)}{\varepsilon(x) - 1} \quad \Rightarrow \quad d\log\frac{p}{c} = -\frac{1}{\varepsilon(\varepsilon - 1)}\varepsilon_x dx = \frac{1}{\varepsilon(\varepsilon - 1)}\left[\frac{\varepsilon + 1}{\varepsilon} - \rho\right]\hat{x}$$

So: $x^* < x \quad \Rightarrow \quad \varepsilon(x^*) > \varepsilon(x) \quad \Rightarrow \quad \dfrac{\varepsilon(x^*)}{\varepsilon(x^*) - 1} < \dfrac{\varepsilon(x)}{\varepsilon(x) - 1} \quad \Rightarrow \quad \dfrac{p^*}{\tau c} < \dfrac{p}{c}$

Proofs (cont.)

- Linking variable cost share $\psi \equiv \frac{cy}{f+cy}$ to elasticities of demand: Back to Text
  - In free trade: $\psi = \frac{cy}{py} = \frac{c}{p} = \frac{p+xp'}{p} = \frac{\varepsilon-1}{\varepsilon}$
  - With trade costs: $\psi = \frac{\bar{\varepsilon}_h - 1}{\bar{\varepsilon}_h}$
    - $\bar{\varepsilon}_h$: A sales-weighted harmonic mean of ε and ε^*
  - Proof:
    - $\psi = \frac{c(x+\kappa\tau x^*)}{px+\kappa p^* x^*}$
    - $\quad = \omega_x \frac{c}{p} + (1-\omega_x)\frac{\tau c}{p^*}$
    - $\quad = \omega_x \frac{\varepsilon-1}{\varepsilon} + (1-\omega_x)\frac{\varepsilon^*-1}{\varepsilon^*}$
    - $\quad = 1 - \frac{1}{\bar{\varepsilon}_h}, \quad \bar{\varepsilon}_h \equiv \left[\omega_x \varepsilon^{-1} + (1-\omega_x)(\varepsilon^*)^{-1}\right]^{-1}$
  - Alternatively: $\psi = \frac{c(x+\kappa\tau x^*)}{px+\kappa p^* x^*} = \frac{c}{\tilde{p}}$
    - $\tilde{p} \equiv \omega_x p + (1-\omega_x)\,\frac{p^*}{\tau}$: A sales-weighted average of the *net* prices received by the firm in the home and foreign markets (p and $\frac{p^*}{\tau}$).

Shares: Summary

- Recap:
  - $\omega_x \equiv \frac{x}{x+\kappa\tau x^*}$: Share of home sales in total output
  - $\omega_\pi \equiv \frac{\pi}{\pi+\kappa\pi^*}$: Share of home market profits in total profits
  - $\omega_u \equiv \frac{u}{u+\kappa u^*}$: Share of utility from home goods in total utility
  - $\omega_z \equiv \frac{z}{z+\kappa z^*}$: Share of home goods in total spending ($z = npx$)
- Special Cases:
  1. Free trade: $\omega_x = \omega_\pi = \omega_u = \omega_z = \frac{1}{1+\kappa}$
  2. CES: $\omega_x = \omega_\pi = \omega_u = \omega_z = \frac{1}{1+\kappa\tau^{1-\sigma}}$
- In general:

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Demand	Utility	
	Subconcave	Superconcave
Subconvex	$\omega_\pi > \omega_z > \{\omega_x, \omega_u\}$	$\{\omega_\pi, \omega_u\} > \omega_z > \omega_x$
Superconvex	$\omega_x > \omega_z > \{\omega_\pi, \omega_u\}$	$\{\omega_x, \omega_u\} > \omega_z > \omega_\pi$

Shares: Proofs

- Rewrite: $\omega_x = \frac{1}{1+\kappa \frac{\tau x^*}{x}}$, $\quad \omega_\pi = \frac{1}{1+\kappa \frac{\pi^*}{\pi}}$, $\quad \omega_u = \frac{1}{1+\kappa \frac{u^*}{u}}$, $\quad \omega_z = \frac{1}{1+\kappa \frac{z^*}{z}}$
- Assume $\tau > 1$ and $x > x^*$ throughout
- $\omega_\pi > \omega_z > \omega_x$ if and only if demands are subconvex (i.e., $\varepsilon < \varepsilon^*$):
  - $p = \frac{\varepsilon c}{\varepsilon - 1} \quad \Rightarrow \quad \frac{z^*}{z} = \frac{p^* x^*}{px} = \frac{\varepsilon^*}{\varepsilon^* - 1} \frac{\varepsilon - 1}{\varepsilon} \frac{\tau x^*}{x} < \frac{\tau x^*}{x} \quad \Rightarrow \quad \omega_z > \omega_x$
  - $\pi = \frac{cLx}{\varepsilon - 1} = \frac{Lpx}{\varepsilon} = \frac{Lz}{\varepsilon} \quad \Rightarrow \quad \frac{\pi^*}{\pi} = \frac{\varepsilon}{\varepsilon^*} \frac{z^*}{z} < \frac{z^*}{z} \quad \Rightarrow \quad \omega_\pi > \omega_z$
- $\omega_u > \omega_z$ if and only if utility is superconcave (i.e., $\xi < \xi^*$):
  - $\xi \equiv \frac{xu'}{u} \quad \Rightarrow \quad \frac{u^*}{u} = \frac{\xi}{\xi^*} \frac{x^*(u^*)'}{xu'} = \frac{\xi}{\xi^*} \frac{p^* x^*}{px} = \frac{\xi}{\xi^*} \frac{z^*}{z} < \frac{z^*}{z} \quad \Rightarrow \quad \omega_u > \omega_z$
- CES: $\varepsilon = \varepsilon^* = \sigma$, $\xi = \xi^*$, $x^* = \tau^{-\sigma} x \quad \Rightarrow \quad \omega_x = \omega_\pi = \omega_u = \omega_z = \frac{1}{1+\kappa \tau^{1-\sigma}}$

Change in Real Income: Details

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- Additive separability: $U = F\left[Nu(x)\right]$
- Budget constraint: $I = \int_{i \in \mathcal{N}} p(i)x(i)di = Npx \quad \Rightarrow \quad x = \frac{I}{Np}$
- Taste for variety requires $\xi < 1$
  - Proof: $Npx = I$, $\hat{p} = \hat{I} = 0 \Rightarrow \hat{x} = -\hat{N} \Rightarrow \hat{U} = (1-\xi)\hat{N}$
- Indirect utility function: $V(N, p, I) = F\left[Nu\left(\frac{I}{Np}\right)\right]$
- Define equivalent income $Y(N, p)$: $\quad V\left(N, p, \frac{I}{Y}\right) = U_0$
  - So: $Nu\left(\frac{I}{NpY}\right)$ is fixed by U_0
  - With $I = wL$ fixed: $\hat{N} = \xi(\hat{N} + \hat{p} + \hat{Y})$
- $\Rightarrow$ Change in Real Income:

$$\hat{Y} = \frac{1-\xi}{\xi}\hat{N} - \hat{p}$$