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

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The Bottom Line

Trade Costs and General Demands: Together at Last!
“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)

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:

- Free trade with additively separable preferences:
  - Krugman (1979)

- Trade costs with non-CES preferences:
  - Bertoletti-Epifani (2012)
  - Arkolakis-Costinot-Donaldson-Rodríguez-Clare (mimeo. 2012)
  - Bykadorov-Kokovin (2012)
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1 Preliminaries

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3 Globalization versus Colder Icebergs

4 Gains from Trade

5 Calibrating Gains from Trade

6 Conclusion
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   - Monopolistic Competition in the Global Economy
   - Superconvex Demands and Superconcave Utility

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Equilibrium in the Global Economy

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

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

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

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

- Market clearing:

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

  Labor-Market Equilibrium: $L = n (f + cy)$
Superconvex Demands and Superconcave Utility

- Perceived demand function:
  \[ p = p(x) \quad p' < 0 \]

- Elasticity:
  \[ \varepsilon(x) \equiv -\frac{p(x)}{xp'(x)} \]
  \[ \text{FOC: } \varepsilon \geq 1 \]

- Convexity:
  \[ \rho(x) \equiv -\frac{xp''(x)}{p'(x)} \]
  \[ \text{SOC: } \rho < 2 \]

- CES:
  \[ p(x) = \beta x^{-\frac{1}{\sigma}} \]
  \[ \varepsilon = \sigma, \quad \rho = \frac{\sigma + 1}{\sigma} > 1 \]

- Superconvexity:
  \[ p(x) \text{ more convex than CES} \]
  \[ \rho > \frac{\varepsilon + 1}{\varepsilon} \]
  \[ \varepsilon \text{ increasing in sales: } \varepsilon_x \geq 0. \]

- Sub-utility function:
  \[ u = u(x) \quad u' > 0, \ u'' < 0 \]

- Elasticity:
  \[ \xi(x) \equiv \frac{xu'(x)}{u(x)} \]
  \[ \text{Taste for variety: } 0 < \xi < 1 \]

- CES:
  \[ u(x) = \frac{\sigma}{\sigma - 1} \beta x^{\frac{\sigma - 1}{\sigma}} \]
  \[ \xi = \frac{\sigma - 1}{\sigma} \]

- Superconcavity:
  \[ u(x) \text{ more concave than CES} \]
  \[ \xi > \frac{\varepsilon - 1}{\varepsilon} \]
  \[ \xi \text{ decreasing in sales: } \xi_x \leq 0. \]
Integrated versus Segmented Markets

- Integrated: Prices equalized allowing for transport costs:
  \[ p^* = \tau p \]

- Segmented: \textit{Marginal revenues} equalized allowing for transport costs:
  \[ r_x = c, \quad r_x^* = \tau c \quad \Rightarrow \quad r_x^* = \tau r_x \]

- These are the same if and only if preferences are CES:
  \[ r_x = \frac{\varepsilon - 1}{\varepsilon} p, \quad r_x^* = \frac{\varepsilon^* - 1}{\varepsilon^*} p^* \]

- Segmented markets and subconvex demands imply \textit{Reciprocal Dumping}:
  - Lower price-cost margins abroad: \[ \frac{p^*}{\tau c} < \frac{p}{c} \]
  - Lower \( \tau \)-inclusive prices abroad: \[ p^* < \tau p \]
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Assume segmented markets

Profit maximization:

\[ r^*_x = \tau r_x \]

\[ \Rightarrow \eta \hat{x} = \eta^* \hat{x}^* + \hat{\tau} \]

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 \( \tau \);
- Independent of \( \kappa \)

CES:

\[ \eta = \eta^* = \frac{1}{\sigma}; \quad x^* = \tau^{-\sigma} x \]
Free Entry

Zero profits:

\[ \pi + \kappa \pi^* = f \]

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

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

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

- \( \omega_{\pi} \): Home market profit share

- \( x^* \) negatively related to \( x \):
  - Decreasing in \( \tau \) and \( \kappa \)

\[ (\varepsilon - 1) \frac{f}{\kappa cL} \]

** CES:**

\[ x + \kappa \tau x^* = (\sigma - 1) \frac{f}{cL} = \frac{y}{L} \]
Equilibrium Sales

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

- \( \pi \)-weighted aggregate elasticity:
  \[ \bar{\varepsilon}_\pi \equiv \omega_\pi \varepsilon + (1 - \omega_\pi) \varepsilon^* \]

- Globalization (\( \kappa \uparrow \)): \( x \downarrow \) \( x^* \downarrow \)
Equilibrium Sales

- Home and export sales:

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

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

- \(\pi\)-weighted aggregate elasticity:

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

- Globalization (\(\kappa \uparrow\)): \(x \downarrow \ x^* \downarrow\)
- Lower \(\tau\): \(x \downarrow \ x^* \uparrow\)

CES: \(\bar{\varepsilon} = \sigma, \bar{\varepsilon} \eta = \bar{\varepsilon} \eta^* = 1\)
Implications for Prices, Output, and Firm Numbers

- **Prices:** \( p = \frac{\varepsilon}{\varepsilon - 1} c, \ p^* = \frac{\varepsilon^*}{\varepsilon^* - 1} \tau c \Rightarrow \hat{p} = \frac{\varepsilon + 1 - \varepsilon \rho}{\varepsilon (\varepsilon - 1)} \hat{x} \), \( \hat{p}^* = \frac{\varepsilon^* + 1 - \varepsilon^* \rho^*}{\varepsilon^* (\varepsilon^* - 1)} \hat{x}^* + \hat{\tau} \)
  - Both increasing with sales if and only if demands are subconvex

- **Intensive margin:** \( y = x + \kappa \tau x^* \Rightarrow \hat{y} = \omega_x \hat{x} + (1 - \omega_x) (\hat{\kappa} + \hat{\tau} + \hat{x}^*) \)
  - \( \omega_x \): Share of home sales in total output
  - In free trade:
    \[
    \hat{y} \bigg|_{\tau=1} = (1 - \omega) \left( 1 - \frac{1}{\varepsilon \eta} \right) (\hat{\kappa} + \hat{\tau})
    \]
    - Positive if and only if \( \eta > \frac{1}{\varepsilon} \ldots \)
    - \ldots 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 \( \tau \) reduces firm output if and only if demand is subconvex.

- **Extensive margin:** \( L = n (f + cy) \Rightarrow \hat{n} = -\psi \hat{y} \)
  - \( \psi \equiv \frac{cy}{f + cy} \): Share of variable costs in total costs
  - Inverse measure of returns to scale; \( \psi = \frac{\varepsilon_h - 1}{\varepsilon_h} \)
  - \( \varepsilon_h \): A sales-weighted harmonic mean of \( \varepsilon \) and \( \varepsilon^* \)
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Gains from Trade

Welfare Change and the Elasticity of Utility

- Measure welfare change by the change in equivalent income, \( Y \):
  \[
  \hat{Y} = \left( \frac{\bar{e}_z}{\bar{e}_u} \frac{1}{\xi_u} - 1 \right) \hat{N}_Y - \omega_Y \hat{p} - (1 - \omega_Y) \hat{p}^* 
  \]

  - \( \xi \equiv \frac{xu'}{u} \): Elasticity of utility

- Near free trade:
  \[
  \hat{Y} \bigg|_{\tau=1} = (1 - \omega) \left( \frac{1 - \xi}{\xi} \hat{K} - \hat{\tau} \right) + \frac{\psi - \xi}{\psi \xi} \hat{n} 
  \]

- 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: \( \tau \downarrow \rightarrow y \downarrow \rightarrow n \uparrow \).
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Calibrating Gains from Trade

- ACRC: 2 sufficient statistics: \( \{ \) home market share, elasticity of import demand \( \} \)

- Calibrating home market shares:
  - \( \omega_x = \omega_\pi = \omega_u \) either in free trade or with CES preferences
  - But not in general

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

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Proofs

- Marginal revenue and price:

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

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

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

So: \[ x^* < x \Rightarrow \varepsilon(x^*) > \varepsilon(x) \Rightarrow \frac{\varepsilon(x^*)}{\varepsilon(x^*) - 1} < \frac{\varepsilon(x)}{\varepsilon(x) - 1} \Rightarrow \frac{p^*}{\tau c} < \frac{p}{c} \]
Proofs (cont.)

- Linking variable cost share \( \psi \equiv \frac{cy}{f + cy} \) to elasticities of demand:
  - In free trade: \( \psi = \frac{cy}{py} = \frac{c}{p} = \frac{p + xp'}{p} = \frac{\varepsilon - 1}{\varepsilon} \)
  - With trade costs: \( \psi = \frac{\overline{\varepsilon}_h - 1}{\varepsilon}_h \)
    - \( \overline{\varepsilon}_h \): A sales-weighted harmonic mean of \( \varepsilon \) and \( \varepsilon^* \)
  - Proof:
    - \( \psi = \frac{c(x + \kappa \tau x^*)}{px + \kappa p^* x^*} \)
    - \( = \omega_x \frac{c}{p} + (1 - \omega_x) \frac{\tau c}{p^*} \)
    - \( = \omega_x \frac{\varepsilon - 1}{\varepsilon} + (1 - \omega_x) \frac{\varepsilon^* - 1}{\varepsilon^*} \)
    - \( = 1 - \frac{1}{\overline{\varepsilon}_h}, \quad \overline{\varepsilon}_h \equiv \left[ \omega_x \varepsilon^{-1} + (1 - \omega_x)(\varepsilon^*)^{-1} \right]^{-1} \)
  - 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:**
  - $\omega_x \equiv \frac{x}{x + \kappa \pi x^*}$: 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:**

<table>
<thead>
<tr>
<th>Demand</th>
<th>Utility</th>
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<tbody>
<tr>
<td>Subconvex</td>
<td>$\omega_\pi &gt; \omega_z &gt; {\omega_x, \omega_u}$</td>
</tr>
<tr>
<td>Superconvex</td>
<td>$\omega_x &gt; \omega_z &gt; {\omega_\pi, \omega_u}$</td>
</tr>
</tbody>
</table>
Shares: Proofs

- Rewrite: \( \omega_x = \frac{1}{1 + \kappa \frac{x^*}{x}}, \ \omega_\pi = \frac{1}{1 + \kappa \frac{\pi^*}{\pi}}, \ \omega_u = \frac{1}{1 + \kappa \frac{u^*}{u}}, \ \omega_z = \frac{1}{1 + \kappa \frac{z^*}{z}} \)

- Assume \( \tau > 1 \) and \( x > x^* \) throughout

- \( \omega_\pi > \omega_z > \omega_x \) if and only if demands are subconvex (i.e., \( \varepsilon < \varepsilon^* \)):
  
  - \( p = \frac{\varepsilon c}{\varepsilon - 1} \Rightarrow \frac{z^*}{z} = \frac{p^* x^*}{p x} = \frac{\varepsilon^*}{\varepsilon - 1} \frac{\varepsilon - 1}{\varepsilon} \frac{\tau x^*}{x} < \frac{\tau x^*}{x} \Rightarrow \omega_z > \omega_x \)
  
  - \( \pi = \frac{cLx}{\varepsilon - 1} = \frac{L p x}{\varepsilon} = \frac{L z}{\varepsilon} \Rightarrow \frac{\pi^*}{\pi} = \frac{\varepsilon^*}{\varepsilon} \frac{z^*}{z} < \frac{z^*}{z} \Rightarrow \omega_\pi > \omega_z \)

- \( \omega_u > \omega_z \) if and only if utility is superconcave (i.e., \( \xi < \xi^* \)):
  
  - \( \xi \equiv \frac{x u'}{u} \Rightarrow \frac{u^*}{u} = \frac{\xi^* x^* (u^*)'}{x u'} = \frac{\xi^*}{\xi^*} \frac{p^* x^*}{p x} = \frac{\xi^*}{\xi^*} \frac{z^*}{z} < \frac{z^*}{z} \Rightarrow \omega_u > \omega_z \)

- CES: \( \varepsilon = \varepsilon^* = \sigma, \ \xi = \xi^*, \ x^* = \tau^{-\sigma} x \Rightarrow \omega_x = \omega_\pi = \omega_u = \omega_z = \frac{1}{1 + \kappa \tau^{1-\sigma}} \)
Additive separability: \( U = F \left[ Nu(x) \right] \)

Budget constraint: \( I = \int_{i \in N} p(i) x(i) \, di = Npx \quad \Rightarrow \quad x = \frac{I}{Np} \)

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 \( Y(N, p) : \quad V(N, p, \frac{I}{Y}) = U_0 \)

So: \( Nu \left( \frac{I}{NpY} \right) \) is fixed by \( U_0 \)

With \( I = wL \) fixed: \( \hat{N} = \xi(\hat{N} + \hat{p} + \hat{Y}) \)

\( \Rightarrow \quad \text{Change in Real Income:} \quad \hat{Y} = \frac{1 - \xi}{\xi} \hat{N} - \hat{p} \)