Selection Effects with Heterogeneous Firms

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Background

- Firms and Trade: Selection Effects

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- Melitz (2003): More efficient firms export

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- More efficient firms more likely to do everything:
    - FDI rather than export: Helpman-Melitz-Yeaple (2004)
    - Internalise rather than outsource: Antràs-Helpman (2004)
    - Pay higher wages: Egger-Kreickemeier (2009), Helpman-Itskhoki-Redding (2010)
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  - Adopt more skill-intensive technology: Bustos (2011)
- Increasingly applied to other fields:
  - International macroeconomics: Ghironi-Melitz (2005)
  - International tax competition: Davies-Eckel (2010)
  - Environmental economics: Forslid-Okubo-Ulltveit-Moe (2011)

Motivation

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    - "Supermodularity" important: substantively? technically?

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    - Distribution of firm productivities: Pareto
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  - If successful firms are large in every dimension, is monopolistic competition the right market structure?
  - A universal tendency? Or are there interesting counter-examples?

Our Contribution

- Distinguish "first-order" and "second-order" selection effects
  - "First-order" much more robust
- General result on second-order selection effects
  - Proved first for a monopoly firm choosing between exports and FDI
  - We then show that it extends to a wide variety of market structures:
    - monopolistic competition, oligopoly;
  - ... and to a wide variety of firm choices:
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- Technical: Application of *supermodularity*
  - Arises very naturally in this context
  - e.g., FDI: Both production costs and market access costs differ by finite amounts
  - Supermodularity imposes a natural restriction on the finite "difference-in-differences" of firm profits

Related Literature

- **Firm Selection**
  - Exports: Melitz (*Em* 2003)
  - FDI: Helpman-Melitz-Yeaple (*AER* 2004)
  - Export-Platform FDI: Helpman-Melitz-Yeaple (WP 2003, Appendix), Mrázová-Neary (2010)
  - Outsourcing: Antràs-Helpman (*JPE* 2004)
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- **Supermodularity**
  - General: Milgrom-Roberts (*AER* 1990), Milgrom-Shannon (*Em* 1994), Athey (*QJE* 2002)
  - Trade:
    - Matching: Grossman-Maggi (*AER* 2000), Costinot (*Em* 2009), Costinot-Vogel (*JPE* 2010)
    - Trade and Environmental Agreements: Limao (*JIE* 2005)
    - Firm Selection: Costinot (WP 2007)

Outline of the Talk

1. First-Order Selection Effects
2. Supermodularity
3. Selection into FDI versus Exporting
4. Selection Effects in Monopolistic Competition
5. Selection Effects in Oligopoly
6. Alternative Firm Choices
7. Summary and Conclusion
8. Supplementary Material

Outline of the Talk

Operating Profits

- Consider a single firm located in one country
- It wishes to serve consumers in a foreign country
- $\pi(t, c)$: Maximum operating profits it can earn; weakly decreasing in:
  - t: Access cost (tariffs and transport costs) it faces
  - c: Exogenous cost parameter (inversely related to productivity)
    - Often, though not always, equal to marginal production cost
    - In some applications, an inverse indicator of quality
  - Other determinants optimally chosen or exogenous; examples later

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  - Total profits: $\Pi^X = \pi(t, c) - f_X < 0$; fixed cost f_X independent of c
  - With $c_1 > c_2$, we have $\pi(t, c_1) < \pi(t, c_2)$
  - So, firm 2 must be the exporter
    - $\Pi_2^X < 0 \Rightarrow \Pi_1^X << 0$; $\Pi_1^X > 0 \Rightarrow \Pi_2^X >> 0$

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- Robust? Very; extends to:
  - Continuum of firms
  - Arbitrary distribution of variable costs
  - Asymmetric countries
  - Arbitrary assumptions about demand and technology
- All that is needed is π decreasing in c: a very mild assumption

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Supermodularity

- Δ_c: The finite difference between the values of a function evaluated at two different values of c:

$$\Delta_c \pi(t, c) \equiv \pi(t, c_1) - \pi(t, c_2) \qquad \text{when} \qquad c_1 \geq c_2$$

  - Non-positive: measures the profit disadvantage of a higher-cost firm
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Definition

The function $\pi (t, c)$ is supermodular in t and c if and only if:

$$\Delta_c \pi (t_1, c) \geq \Delta_c \pi (t_2, c) \qquad \text{when} \qquad t_1 \geq t_2.$$

Implications

Supermodularity: Some Intuition

$$\Delta_c \pi (t_1, c) \geq \Delta_c \pi (t_2, c)$$

$$\Rightarrow \quad 0 \geq \pi (t_1, c_1) - \pi (t_1, c_2) \geq \pi (t_2, c_1) - \pi (t_2, c_2)$$

- A higher tariff reduces in absolute value the profit disadvantage of a higher-cost firm.

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- The "Matthew Effect": "To those who have, more shall be given":
  - A lower tariff is of more benefit to a firm with more sales
  - A lower-cost (more productive) firm usually has higher sales
  - ... though not always ...

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- Analogous to Hicksian complementarity in consumer theory or strategic complementarity in game theory

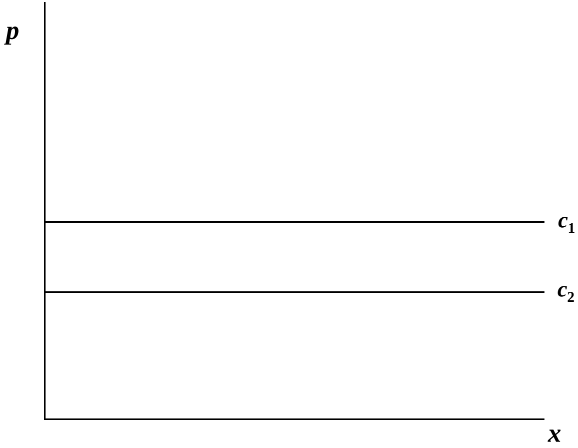
Example 1: Marginal Cost Independent of Output

- Constant marginal cost c
- Inverse demand function: $p(x)$
- So, firm's operating profits equal:

$$\pi(t, c) \equiv \underset{x}{Max} \left[\{p(x) - c - t\} x \right]$$

▸ Maths

Example of Supermodularity



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- And therefore ...

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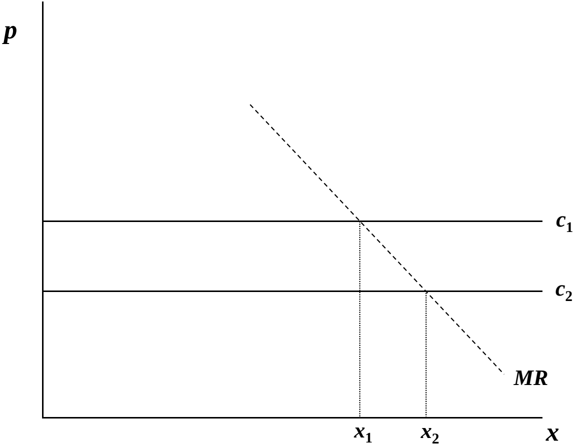


- Less productive firm has higher marginal cost
- And therefore lower output, so it benefits less from a tariff reduction.

Example 2: Marginal Cost Varies with Output

- Key features of Example 1: π continuous in t and c *and* depends only on their sum
  - Given these, supermodularity $\Leftrightarrow$ *convexity* of π in both t and c

Example 2: Marginal Cost Varies with Output

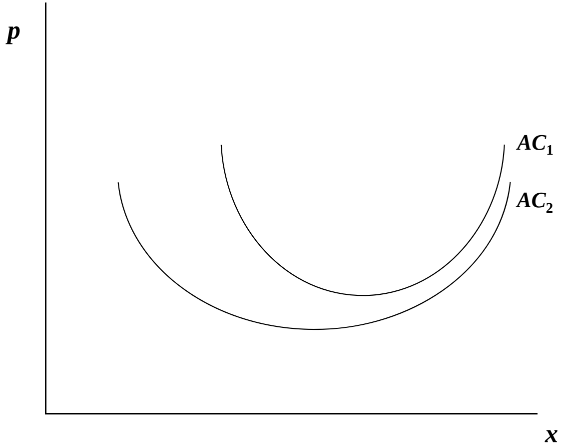
- Key features of Example 1: π continuous in t and c *and* depends only on their sum
  - Given these, supermodularity $\Leftrightarrow$ *convexity* of π in both t and c
- Suppose instead that marginal cost varies with output:

$$\pi(t, c) \equiv \underset{x}{Max}\left[\{p(x) - t\}\, x - C(c, x)\right]$$

  - $C(c, x)$: Total variable costs; $C_c > 0$, $C_x > 0$

Maths

Example of Submodularity



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- So much so that ...

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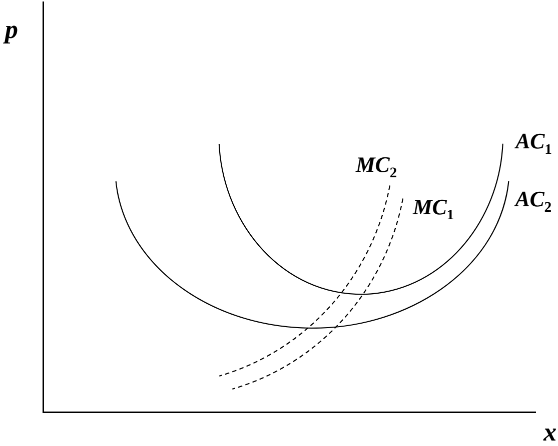

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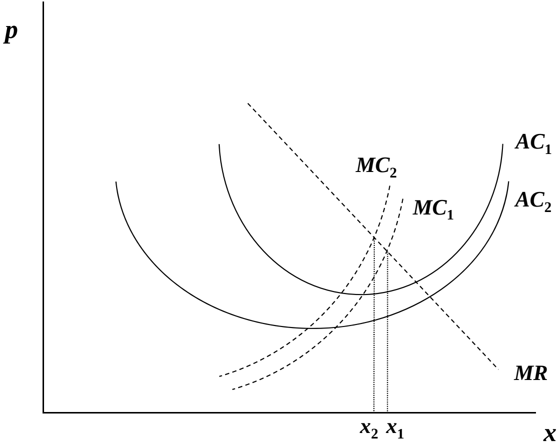

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- So much so that it has *lower* marginal cost and *higher* output

Example 2: Conclusion

- Example 2 provides an exception to supermodularity because inter-firm differences in efficiency work in opposite directions *on average* and *at the margin*.
- Supermodularity holds as long as they work in the same direction.

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The Tariff-Jumping Gain

- Firm has two options:
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  - Concentration: Exports incur a lower fixed cost: $f_X < f_F$
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- Define the *tariff-jumping gain* γ:

$$\gamma(t, c, f) \equiv \pi(0, c) - \pi(t, c) - f = \Pi^F - \Pi^X$$

  - $f \equiv f_F - f_X > 0$ is the excess fixed cost of FDI relative to exporting

Firm Selection into Tariff-Jumping

$$\gamma(t, c, f) \equiv \pi(0, c) - \pi(t, c) - f$$

- Apply Δ_c to the tariff-jumping gain:

$$\Delta_c \gamma(t, c, f) = \Delta_c \pi(0, c) - \Delta_c \pi(t, c)$$

- From the definition of supermodularity, $\Delta_c \gamma(t, c, f)$ is negative if and only if π is supermodular in t and c

▸ Recall definition

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- Since γ measures the incentive to engage in FDI relative to exporting:

Proposition

If and only if the profit function π is supermodular in t and c, higher-cost firms will serve the foreign market by exports, while lower-cost firms will serve it via FDI, for all admissible f.

Skip technical details

Technical Details of Proof

- Sufficiency is immediate:
  - SM [Supermodularity of π in t and c] $\Rightarrow \gamma$ weakly decreasing in c
  - $\Rightarrow$ Selection, if it occurs, must follow the CS pattern
    - CS ["Conventional Sorting"]: High-cost firms export, low-cost in FDI

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  - So, SM is also necessary
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    - $f \in (0, \overline{f})$, where $\overline{f} \equiv \max_c \gamma(t, c, 0)$ for given $t > 0$
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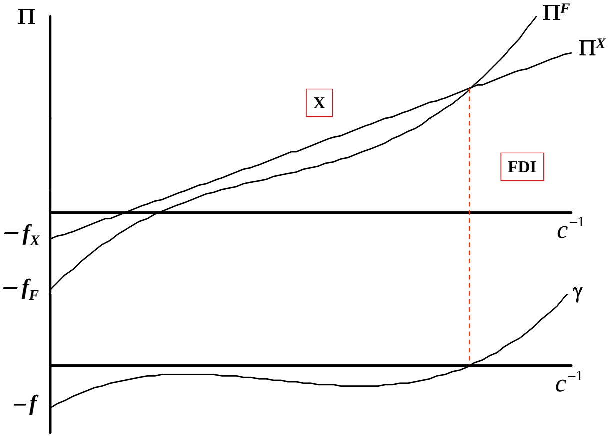
Formal proof

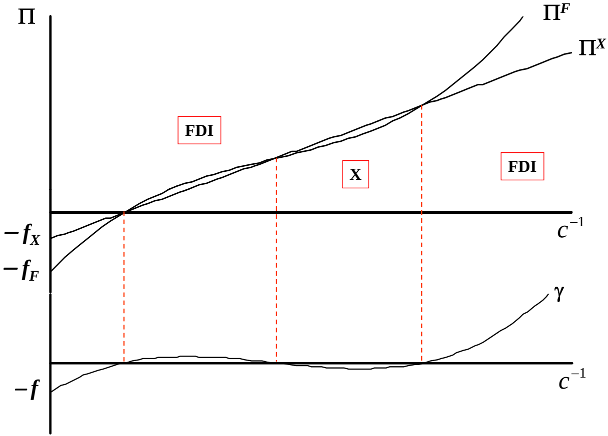
- None of this matters in many practical applications
  - Mostly we assume π is differentiable
  - So sufficiency is sufficient: we need only check if π_{tc} is non-negative
  - Since: $\pi_{tc} \geq 0 \Rightarrow$ SM $\Rightarrow$ SCP $\Rightarrow$ CS
  - Next

SCP But Not SM



- SCP holds but not SM, and so CS holds for *some* f

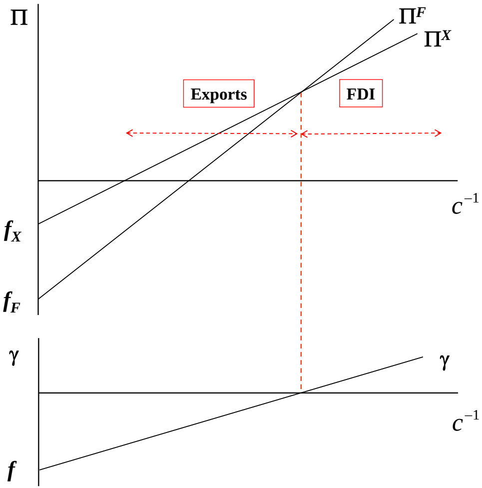
Not SM $\Rightarrow$ Not SCP for some f



- SM does not hold, so we can always find an f such that SCP and so CS does not hold

Back

SM $\Rightarrow$ SCP



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  - Things are different if they depend on t and c: see below
- Proposition 1 generalises the result of Helpman-Melitz-Yeaple (2004)
- ... or does it?

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Selection Effects with CES Preferences

- As in Helpman-Melitz-Yeaple: CES preferences $x = Ap^{-\sigma}$
- Profits: $\pi(t, c) = (\tau c)^{1-\sigma} B$
    - $\tau = 1 + t \geq 1$: Iceberg transport cost
    - $\sigma > 1$: Elasticity of substitution
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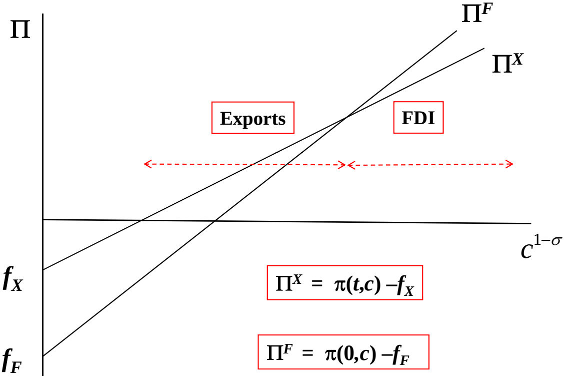
- No: Cross-section comparison between two different firms only, both of measure zero

Inferring Selection Effects the Hard Way



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  - Parallel with GE results: Maskin-Roberts (*ET* 2008)

Selection Effects with CES Preferences II

- Usual approach (HMY): Compute equilibrium, check selection effects
- Our approach: *Assume* an equilibrium exists
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  - SM: $\Delta_c \pi(t,c) > \Delta_c \pi(0,c)$

$$\Leftrightarrow \quad \pi(t,c_1) - \pi(t,c_2) > \pi(0,c_1) - \pi(0,c_2)$$

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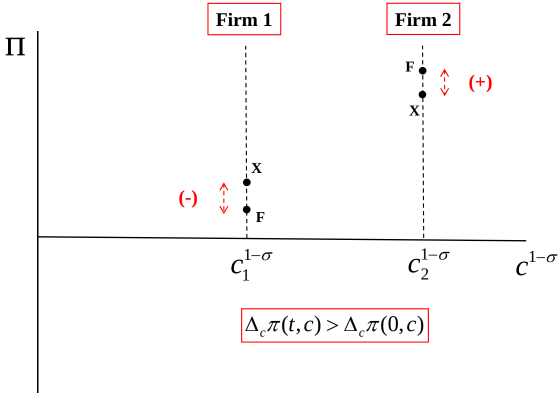
  - Now subtract $f = f_F - f_X$ from both sides:

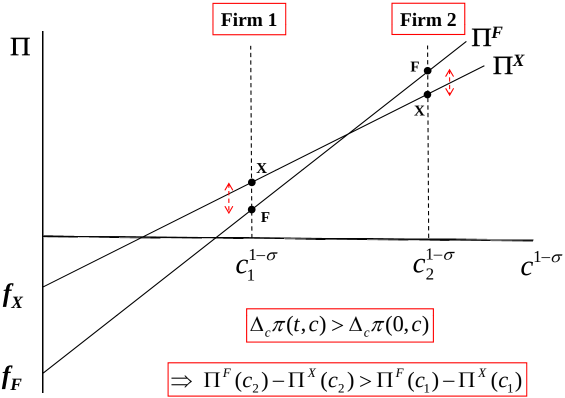
$$\Leftrightarrow \quad \Pi^F(c_2) - \Pi^X(c_2) > \Pi^F(c_1) - \Pi^X(c_1)$$

  - Repeat for every pair of firms ...

Selection Effects: Two Tiny Firms at a Time



Inferring Selection Effects from Supermodularity



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Selection Effects with General Preferences II

- Write demand elasticity as a function of x: $\varepsilon(x) \equiv -\frac{\partial x}{\partial p}\frac{p}{x} = -\frac{p}{xp'}$
  - Krugman (1979): $\varepsilon_x < 0$ (e.g., quadratic, Stone-Geary, CARA, logistic)
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With iceberg transport costs, the profit function is supermodular in t and c for all levels of output if the demand function is superconvex, $\varepsilon_x \geq 0$.

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- By contrast, if $\varepsilon_x < 0$, submodularity may hold for sufficiently high x.

Selection Effects with General Preferences III

- Submodularity possible whenever $\varepsilon_x < 0$:

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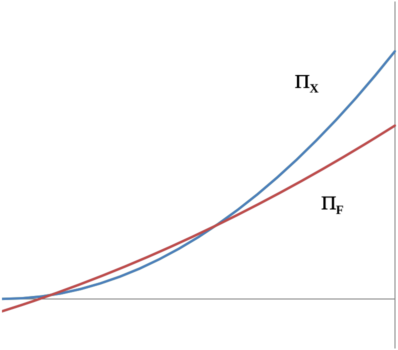
Proposition

With general demands and iceberg transport costs, the profit function is supermodular in t and c if and only if: $\varepsilon + \rho - 3 \geq 0$.

$$\pi_{tc} = -x - \tau c \tilde{\pi}_{xx}^{-1} = -x - \frac{p + xp'}{2p' + xp''} = \frac{\varepsilon + \rho - 3}{2 - \rho} x$$

- So: Submodularity more likely for less elastic and more concave demand

Quadratic Preferences; Iceberg Transport Costs



Quadratic preferences (Melitz-Ottaviano (2008), Nefussi (2006)) ▸ Details

▸ Compare Ad Valorem Case

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- BUT: Separability of π does not hold if c measures quality

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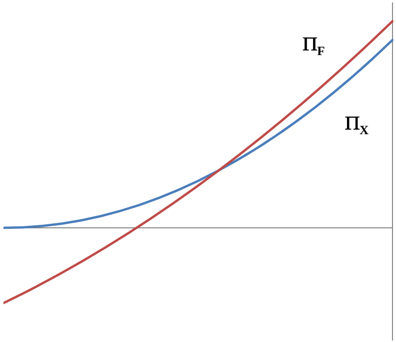

Compare Iceberg Case

Summary: Monopolistic Competition

- Is the profit function always supermodular?

Preferences:	$\varepsilon_x \geq 0$	$\varepsilon_x < 0$
Iceberg transport costs:	Yes	No
Proportional transport costs:	Yes	Yes

Outline of the Talk

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  - Though need to be careful in considering boundary cases
  - Examples:
    - Leahy-Montagna (2009): Outsourcing
    - Porter (2011): FDI

Outline of the Talk

Alternative Firm Choices

- So far, focus on choice between exports and FDI only
- Analogous results apply to other firm choices:
  - Export-platform versus multi-plant FDI ▸ Details
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  - In each case, supermodularity (between firm's cost parameter and a parameter representing the marginal cost of the choice variable) is necessary and sufficient for the standard selection effect
- Of course, this does not apply to first-order selection effects; e.g., choice between serving a market or not:
  - Melitz (2003): Export decision
  - Depends *only* on $\pi(t, c) - f_X$
  - π decreasing in c ensures conventional sorting.
- Melitz result is very robust.

▸ Skip to Next Section

Vertical Disintegration

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- Firm/HQ chooses organizational form to maximize "realized" profits:
  - $\pi(w, \psi, c) \equiv Max_x (1-\psi)[p(x) - wc]\, x$
  - Wages: w_N in North, w_S in South, $w_N > w_S$
  - ψ: profit loss due to incomplete contracting between HQ and supplier
    - Structural microfoundations in Antràs-Helpman (2004)
  - No transport costs

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Produce in North or South:	$\pi(w, c) = (p - wc)x$	Yes	No
Produce in-house or outsource:	$\pi(\psi, c) = (1 - \psi)(p - wc)x$	Yes	Yes

- Composite VFDI case with $\psi_N < \psi_S$ and $w_N > w_S$ ambiguous

Skip to Conclusion

Heterogeneous Fixed Costs

- Analysis unaffected if fixed costs depend on t only
  - e.g. Kleinert-Toubal (2006, *RIE* 2010):
    - Fixed costs rising with distance rationalize a gravity equation for FDI
    - and avoid counter-factual prediction that falling trade costs lower FDI
    - But selection effects are unchanged
    - Why? Δ_c operator applied to γ eliminates $f_F(t)$

Heterogeneous Fixed Costs II

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  - Example 2: Oldenski (2009): Task-based trade in services
    - Higher-productivity firms in service sectors are more vulnerable to contract risk when located abroad;
    - Now: $\Delta_c f_F(c) = f_F(c_1) - f_F(c_2) \leq 0$, so $\pi(t, c)$ may be submodular
    - Conventional sorting may be reversed: higher-productivity firms may find it more profitable to locate at home.

Endogenous Fixed Costs

Skip to Conclusion

- Assume firm invests in market-specific process R&D
    - Similar results apply to advertising, marketing, etc. (Arkolakis *JPE* 2010)
- ... and costs vary continuously in investment
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$$\pi(t,c) \equiv \underset{x,k}{Max}\left[\{p(x) - C(c,k) - t\}x - F(k)\right]$$

c :	Firm's cost level or inverse productivity (exogenous, as before)
k :	Investment in cost-reducing R&D (endogenous)
$C(c,k)$:	Marginal production cost: increasing in c, decreasing in k
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- Supermodularity may not hold if $C_{kc} << 0$
- i.e., if investment lowers the cost disadvantage of a lower productivity firm
- This cannot happen in some commonly-used special cases ...
- ... But: We can find examples exhibiting submodularity ...

Endogenous Fixed Costs: Details

$$\pi(t,c) \equiv \underset{x,k}{Max}\left[\{p(x) - C(c,k) - t\}x - F(k)\right]$$

Proposition

$\pi(t,c)$ is supermodular in (t,c) if $C(c,k)$ is supermodular in (c,k).

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$$C(c,k) = c_0 + c\phi(k), \qquad F'' = 0$$

Lemma

$\pi(t,c)$ is supermodular in (t,c) if and only if $\phi(k)$ is log-convex in k.

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$\pi(t,c)$ is supermodular in (t,c) if and only if $\phi(k)$ is log-convex in k.

- $\pi(t,c_0,c)$ is always supermodular in (t,c_0)
- Second-order condition requires: $xC_{kk} + F'' > 0 \Rightarrow C_{kk} > 0$ if $F'' = 0$
  - So, when $F'' = 0$, C must be convex in k, but need not be log-convex.

Skip Proofs

Endogenous Fixed Costs: Proofs

Proof of Proposition:

- Supermodularity again depends on sign of x_c: $\pi_{tc} = -x_c$
- First-order conditions: $p - C - t + xp' = 0$ and $-xC_k - F' = 0$

$$\Rightarrow \begin{bmatrix} 2p' + xp'' & -C_k \\ -C_k & -(xC_{kk} + F'') \end{bmatrix} \begin{bmatrix} dx \\ dk \end{bmatrix} = \begin{bmatrix} C_c dc + dt \\ xC_{kc} dc \end{bmatrix}$$

$$\Rightarrow \pi_{tc} = -x_c = \underset{+}{D}^{-1} \left[\underbrace{C_c \left(xC_{kk} + F'' \right)}_{+} - \underset{-}{xC_k C_{kc}} \right]$$

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  - Second-order conditions: $D > 0$ (determinant) and $xC_{kk} + F'' > 0$
  - ... both of which work in favour of $x_c < 0$ and so of supermodularity
  - But: supermodularity could still fail if $C_{kc} << 0$

Proof of Lemma:

- $C(c,k) - c_0 = c\phi(k)$ log-convex in $k \Leftrightarrow C_k C_{kc} - C_c C_{kk} < 0$.
  - $\Phi(k) \equiv \ln \phi(k)$; $\Phi'' > 0 \Leftrightarrow \phi\phi'' - (\phi')^2 > 0$
  - $C_k C_{kc} - C_c C_{kk} = c\left[(\phi')^2 - \phi\phi''\right]$

Endogenous Fixed Costs: Special Cases

1. d'Aspremont-Jacquemin (*AER* 1988): $C(c,k) = c_0 - c^{-1}k, \;\; F(k) = \frac{1}{2}\gamma k^2$
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2. Spence (*Em* 1984): $C(c,k) = c_0 + ce^{-\theta k}, \;\; F(k) = k$
   - $C_{kc} < 0$; but only negative enough to make $\pi_{tc} = 0$
   - $C(c,k) - c_0 = ce^{-\theta k}$ is log-*linear* in k
   - $x_c = 0$, so π is *modular* in (t,c)
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   - All firms produce the same level of output (though more productive firms invest less and make higher profits)

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   - So: No selection effects in the Spence case
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- However, a less convex R&D cost function can be submodular ...
- ... as well as being economically interesting ...

Example of Submodularity

3. $C(c,k) = c_0 + ce^{-\theta k^a}$:

- $a = 1$: Spence (1984); $a = 2$: Gaussian function

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   - $\rightarrow$ firm selection into proximity versus concentration reversed

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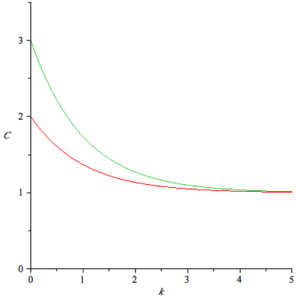

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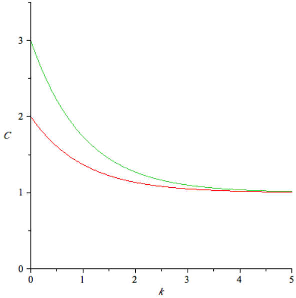

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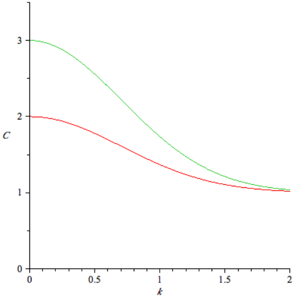

$a = 2$

Outline of the Talk

Summary and Conclusion

- First-order selection effects very robust (e.g. Melitz (2003))
- Second-order selection effects less robust
  - Supermodularity of profits in tariffs and production costs is necessary and sufficient for "conventional sorting"
    - More efficient firms engage in FDI, less efficient in exporting
    - Fixed costs may not predict outcome, except in CES case
- Result holds under a variety of assumptions about market structure and extends to a broad range of models
- Supermodularity pervasive but not universal; counter-examples:
  - FDI without CES: Horizontal with icebergs, or Vertical
  - Task-based trade in services
  - Threshold effects in R&D
- Technique very easy to apply analytically

Thank you for listening. Comments welcome!

Outline of the Talk

1. First-Order Selection Effects
2. Supermodularity
3. Selection into FDI versus Exporting
4. Selection Effects in Monopolistic Competition
5. Selection Effects in Oligopoly
6. Alternative Firm Choices
7. Summary and Conclusion
8. **Supplementary Material**
   - Examples 1 and 2

Examples 1 and 2

- Example 1: $\pi(t,c) \equiv \underset{x}{Max}\left[\{p(x) - c - t\}\, x\right]$
  - From the envelope theorem: $\pi_t = -x(t,c)$.
  - Hence the second cross-partial derivative is positive: $\pi_{tc} = -x_c > 0$.
    - Proof: The first-order condition is: $p - c - t + xp' = 0$
    - Differentiate this to get: $dx = -H^{-1}dc$
    - $H \equiv -(2p' + xp'') > 0$ from second-order condition
    - $\Rightarrow \pi_{tc} = -x_c = H^{-1} > 0$
  - So π is supermodular in t and c.

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- Example 2: $\pi(t,c) \equiv \underset{x}{Max}\left[\{p(x) - t\}\, x - C(c,x)\right]$
  - Envelope theorem still holds: $\pi_t = -x(t,c)$

$$\Rightarrow \pi_{tc} = -x_c = H^{-1}C_{xc}$$

  - $H \equiv -\left[2p' + xp'' - (2C_x + xC_{xx})\right] > 0$ from second-order condition
  - But π is *submodular* if C_{xc} is negative

Back

Proof of Proposition 1

- Proof of Necessity:
  - Let $t > 0$.
  - If π is not supermodular in t and c, then there exist some c_1 and c_2 such that $c_1 > c_2$ and $\pi(t, c_1) - \pi(t, c_2) < \pi(0, c_1) - \pi(0, c_2)$.
  - Rearranging terms gives: $G_1 > G_2$, $\quad G_1 \equiv \pi(0, c_1) - \pi(t, c_1)$, $G_2 \equiv \pi(0, c_2) - \pi(t, c_2)$

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  - Set f such that: $f = \frac{1}{2}(G_1 + G_2)$.
  - For this f, we have: $\gamma(t, c_1, f) = G_1 - f = \frac{1}{2}(G_1 - G_2) > 0$ and $\gamma(t, c_2, f) = G_2 - f = \frac{1}{2}(G_2 - G_1) < 0$.
  - Since γ measures the incentive to engage in FDI relative to exporting, the higher-cost firm will serve the foreign market via FDI while the lower-cost firm will serve it by exports.
- So, if SM does not hold, we can find some f such that CS is reversed.
- So, SM is necessary for CS

Back

Proof of Proposition 3

We want to express π_{tc} in terms of ε and ε_x: ▸ Return

$$\varepsilon\left(x\right)=-\frac{p(x)}{xp'(x)}\rightarrow\varepsilon_x=-\frac{1}{x}+\frac{p\left(p'+xp''\right)}{\left(xp'\right)^2}$$

$$\rightarrow 2p'+xp''=-\frac{p}{x\varepsilon^2}\left(\varepsilon-1-x\varepsilon_x\right)<0$$

$$p-\tau c+xp'=0\rightarrow\tau c=p+xp'=p-\frac{p}{\varepsilon}=\frac{\varepsilon-1}{\varepsilon}p$$

Finally, substitute these results into π_{tc}:

$$\pi_{tc}=-x-\tau c\left(2p'+xp''\right)^{-1}=-x+\frac{\varepsilon-1}{\varepsilon-1-x\varepsilon_x}\varepsilon x$$

Collecting terms gives the desired expression:

$$\pi_{tc}=\frac{\left(\varepsilon-1\right)^2+x\varepsilon_x}{\varepsilon-1-x\varepsilon_x}x$$

Example: Quadratic Preferences

- Quadratic preferences:

Back

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Back

- Quadratic preferences:
  - $p = A - bx \;\Rightarrow\; p' = -b,\; p'' = 0,\; H = 2b$
  - FOC: $p - \tau c - bx = 0 \;\Rightarrow\; x = \frac{1}{2b}(A - \tau c)$
  - $\Rightarrow$ Maximized operating profits: $\pi(t, c) = bx^2 = \frac{1}{4b}(A - \tau c)^2$
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  - So: *Super*-modular for high-cost firms:
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    - Highest-cost firms likely to export (depending on threshold values)
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    - High $c \Rightarrow 2\tau c > A \Rightarrow \pi_{tc} > 0$
    - Highest-cost firms likely to export (depending on threshold values)
    - Mid-cost ones engage in FDI
  - But: *Sub*-modular for low-cost firms!
    - Low $c \Rightarrow 2\tau c < A \Rightarrow \pi_{tc} < 0$
    - Lowest-cost/most productive firms export

Exports vs FDI with Many Countries

- Assume firm wants to serve n identical foreign countries [e.g., EU]
  - Same inverse demand function $p(x)$ in each
  - Results as before if both intra-EU and transatlantic tariff equal t.

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- Profits from establishing plants in m member countries and exporting from them to the remaining $n - m$ countries:

$$\Pi^{Fm} = m\left[\pi(0, c) - f_F\right] + (n - m)\left[\pi(t_U, c) - f_X\right]$$

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- Define the *export-platform gain*: $\phi(t, t_U, c) \equiv \pi(t_U, c) - \pi(t, c) > 0$

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  - Linear in m, so optimal m is either one or n

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- Profits from establishing plants in m member countries and exporting from them to the remaining $n - m$ countries:

$$\Pi^{Fm} = m\left[\pi(0, c) - f_F\right] + (n - m)\left[\pi(t_U, c) - f_X\right]$$

- Define the *export-platform gain*: $\phi(t, t_U, c) \equiv \pi(t_U, c) - \pi(t, c) > 0$

$$\rightarrow \Pi^{Fm} - \Pi^X = m\gamma(t, c, f) + (n - m)\phi(t, t_U, c)$$

  - Linear in m, so optimal m is either one or n
  - So, a firm that engages in FDI will establish either a single export-platform plant or n plants, one in each country.
  - Assumption of constant marginal cost c is crucial here.

Profitable Modes of Serving Foreign Markets

- Gain from multi-market FDI relative to export-platform FDI:

$$\Pi^{Fn} - \Pi^{F1} = (n-1)\left[\gamma\left(t,c,f\right) - \phi\left(t,t_U,c\right)\right]$$

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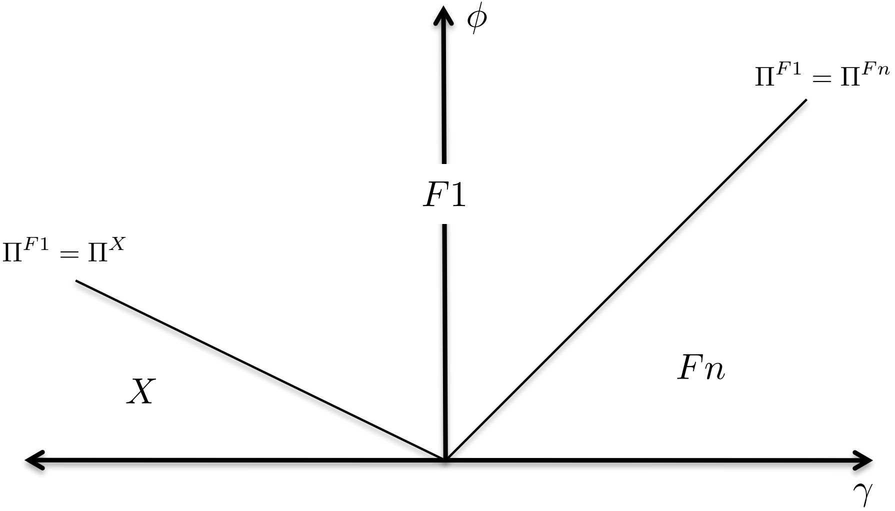
- Summarising the results so far:

Lemma

There are only three profitable modes of serving the n markets: exporting to all, export-platform FDI (with one plant), and multi-market FDI (with n plants).

Figure: Profitable Modes of Serving Foreign Markets



Firm Selection

- Export-platform FDI versus exports:

$$\Delta_c \left(\Pi^{F1} - \Pi^{X}\right) = \Delta_c \gamma \left(t, c, f\right) + \left(n - 1\right) \Delta_c \phi \left(t, t_U, c\right) \tag{1}$$

  - If and only if π is supermodular in t and c, both $\Delta_c \gamma \left(t, c, f\right)$ and $\Delta_c \phi \left(t, t_U, c\right)$ are negative, so (1) is negative

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- Multi-market versus export-platform FDI:

$$\begin{aligned} \Delta_c \left(\Pi^{Fn} - \Pi^{F1}\right) &= (n-1)\,\Delta_c \left[\gamma\left(t, c, f\right) - \phi\left(t, t_U, c\right)\right] \\ &= (n-1)\,\Delta_c \gamma\left(t_U, c, f\right) \end{aligned}$$

  - This too is negative if and only if profits are supermodular in t and c

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  - This too is negative if and only if profits are supermodular in t and c

Proposition

If and only if π is supermodular in t and c, then the least efficient firms that serve foreign markets will do so via exporting, the next most efficient via export-platform FDI, and the most efficient via multi-market FDI, for all admissible f.

- More effective worker screening: Helpman-Itskhoki-Redding (*Em* 2010)