Does Improved Market Access Raise Plant-Level Productivity?

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**Motivation**

Exporters are more productive than nonexporters. Does exporting raise productivity?

1. Raising productivity is not a passive activity.
   ◦ e.g., learning-by-exporting, down the AC curve.

2. What is the policy-relevant question being answered or policy-relevant parameter being estimated?

   ◦ Results for developing countries are more mixed, possibly because of differences in why firms export.
Basic Insight

• Estimate effects of a policy – improved market access.

• Improved market access leads to reorganization:

• Heterogeneity: Firms with low levels of productivity who reorganize and export must be getting a big kick from reorganization.
Why reorganization rather than conventional explanations?

- Moving down and average cost curve — Not a big enough effect (Lileeva, Ph.D., 2005)

- Bilateral tariff reductions under monopolistic competition leads to import competition which raises productivity — No (Trefler, *AER*, 2004)

- Changes in product mix — Yes? (Baldwin, Caves, and Beckstead, Mimeo, 2004).

The strategic management literature often claims that there are benefits Mork and Yueng (*JB*, 1991), Baily and Gersback (*Brookings*, 1995), Berry and Sakakibara (*JEOB*, 2005), Cassiman and Martínez-Ros (Mimeo, 2005), Salomon and Shaver (*JEMS*, forthcoming)
Figure 1. Number of Products per Multi-Product Plant

Product Dispersion
(A measure of the number of products produced per plant)

A Simple Model of Optimizing Behaviour

- Optimization problem only: Ignore markets and focus on selection.
- Static, full information.
- No general equilibrium feedbacks.
Demand

• Two countries, home (Canada) and foreign (‘∗’, United States)
• CES monopolistic competition. A home firm producing variety $i$ faces demands

$$q(i) = p(i)^{-\sigma} A \text{ and } q^*(i) = p^*(i)^{-\sigma} A^*.$$ 

• The foreign country imposes a tariff $\tau(i) - 1$ on firm $i$’s products.
Cost

• A standardized bundle of inputs costs $c$ and produces $\varphi(i)$ units of output. Hence marginal costs are:

$$\frac{c}{\varphi(i)}$$

Profit Maximization

• Profit maximizing prices are

$$p(i) = \frac{\sigma}{\sigma - 1} \frac{c}{\varphi(i)} \text{ and } p^*(i) = \tau(i)p(i).$$
Entry into Export Markets

• A fixed cost $F^E$ must be incurred to enter the foreign market. Let $E(i) = 1$ if the firm enters and $E(i) = 0$ if it does not enter.

• Home firm’s profits are (dropping the $i$ index)

$$\pi(E) = \tilde{\phi} \left[ A + E \tau^{-\sigma} A^* \right] - EF^E$$

for $E = 0,1$ where

$$\tilde{\phi} = \frac{(\sigma - 1) \sigma^{-1} \sigma^{-\sigma}}{c^{\sigma-1}} \phi^{\sigma-1}.$$

• Enter foreign markets when

$$\tilde{\phi} > \bar{\phi} \equiv \frac{F^E}{\tau^{-\sigma} A^*}.$$

where $\tau^{-\sigma} A^*$ measures the size of the foreign market.
Reorganizing to Raise Productivity

- The firm can choose to pay a fixed ‘reorganization’ cost $F^R$ that raises productivity from $\varphi_0$ to $\varphi_1$.
- $\varphi_0$ and $\varphi_1$ are known.
- Let $R = 1$ if the firm reorganizes, $R = 0$ if not.
- Profits are

\[
\pi(R = 1, E) = \tilde{\varphi}_1 \left[ A + E \tau^{-\sigma} A^* \right] - EF^E - F^R
\]

\[
\pi(R = 0, E) = \tilde{\varphi}_0 \left[ A + E \tau^{-\sigma} A^* \right] - EF^E
\]
\[ \phi_1 - \phi_0 \]
\[ \varphi_1 - \varphi_0 \]

\[ \frac{F^R + F^E}{A + \tau^{-\sigma} A^*} \]

\[ \frac{F^R}{A + \tau^{-\sigma} A^*} \]

Export
Reorganize

No Exporting
No Reorganization

Exporting
Reorganize

\[ \varphi = \frac{F^E}{\tau^{-\sigma} A^*} \]

\[ \frac{F^R + F^E}{\tau^{-\sigma} A^*} \]
\( \phi_1 - \phi_0 \)

\[
\frac{F^R + F^E}{A + \tau^{-\sigma} A^*}
\]

\[
\frac{F^R}{A + \tau^{-\sigma} A^*}
\]
\[ \varphi_1 - \varphi_0 \]

\[ \frac{F^R + F^E}{A + \tau^{-\sigma} A^*} \]

\[ \frac{F^R}{A + \tau^{-\sigma} A^*} \]
Improved market access induces reorganization and exporting

\[ \frac{F^R + F^E}{A + \tau^{-\sigma} A^*} \]

\[ \frac{F^R}{A + \tau^{-\sigma} A^*} \]
Improved market access induces reorganization and exporting.

Induces exporting without reorganization.
Causal Effects of Improved Market Access on Productivity Growth
Causal Effects of Improved Market Access on Productivity Growth

• For a firm that is initially indifferent between exporting and not exporting.

• Assume

\( \frac{F^E}{\tau^{-\sigma} A^*} < \frac{F^R}{A} \)

• If low \( F^R \), reorganize immediately – lack of dynamics.

• If \( A^* \) is higher for low \( \varphi_0 \) firms then the line is lower (and steeper).

• Expect opposite results if \( F^R \) is higher for low \( \varphi_0 \) firms (but functional form kills this).
Econometric Model

\[ \Delta \varphi_0 = \beta_0(X) + U_0 \]  
\[ \Delta \varphi_1 = \beta_1(X) + U_1 \]  
\[ E = \begin{cases} 1 & P(X,\Delta \tau) \geq U_E \\ 0 & P(X,\Delta \tau) < U_E \end{cases} \]

- where \( X \) includes \( \varphi_0 \) and \( P(X,\Delta \tau) \equiv \Pr\{ E = 1 | X, \Delta \tau \} \)

- Causal Effects of Improved Market Access (suppress \( X \)):
  \[ C = \Delta \varphi_1 - \Delta \varphi_0 = (\beta_1 - \beta_0) + (U_1 - U_0) \]

- \( U_1 \neq U_0 \) means heterogeneous causal effects.
Importance of Conditioning on $U_E$

• Consider a firm on our line. Set $X = \varphi_0$:

$$P(\varphi_0, \Delta\tau = 0) = U_E.$$ 

• $P(\varphi_0, \Delta\tau = 0)$ is increasing in $\varphi_0$. On the line, firms with a small $\varphi_0$ have:

  ◦ A small $U_E = P(\varphi_0, \Delta\tau = 0)$.
  ◦ A large $U_1 - U_0$.

$\Rightarrow U_E$ and $U_1 - U_0$ are negatively correlated

• Conditioning on $U_E$ is informative. Our object of interest is

$$E[\beta_1 - \beta_0 + U_1 - U_0 | \varphi_0, U_E = P(\varphi_0, \Delta\tau)]$$ (1)

or

$$E[C | P].$$ (2)
Importance of Conditioning on $U_E$

- CES example: Go back to the old notation so that $\Delta \varphi_i$ is replaced by $\varphi_i = \beta_i + U_i$. For simplicity set $U_0 = 0$. Then on our line

$$\beta_1 - \left[ \frac{A\beta_0^{1/(\sigma-1)} + F^E + F^R}{A + \tau^{-\sigma} A^*} \right]^{\sigma-1} = -U_1$$

$P$

where $\partial P / \partial \tau < 0$ so that a higher tariff makes entry less likely.
Estimation of the Line — $E(C|P)$

Observables With Heterogeneity ($U_1 \neq U_0$)

\[ \Delta \varphi = \Delta \varphi_0 + (\Delta \varphi_1 - \Delta \varphi_0)E \]
\[ = \beta_0 + U_0 + [(\beta_1 - \beta_0) + (U_1 - U_0)]E \]

\[ C = (\beta_1 - \beta_0) + (U_1 - U_0) \]

Observables Without Heterogeneity ($U_1 = U_0$)

\[ \Delta \varphi = \beta_0 + (\beta_1 - \beta_0)E + U_0 \]
\[ C = \beta_1 - \beta_0 \]
Estimation with No Heterogeneity

\[ E[\Delta \phi | E] = \beta_0 + (\beta_1 - \beta_0) E + E[U_0 | E] \]

\[ C^{OLS} = \frac{\Delta \phi}{E=1} - \frac{\Delta \phi}{E=0} \quad C^{IV} = \frac{\Delta \phi}{E=1} - \frac{\Delta \phi}{E=0} \]

\[ E[\Delta \phi | P] = \beta_0 + (\beta_1 - \beta_0) P + E[U_0] \]

- Local IV using plants with the same
  \[ \hat{P}^{\Delta \tau = 0} \equiv P(X, \Delta \tau = 0) \text{ and } \hat{P}^{\Delta \tau = 1} \equiv P(X, \Delta \tau = 1) \]
  \[ \hat{E}[C | P] = \frac{\Delta \phi}{\hat{P}^{\Delta \tau = 1}} - \frac{\Delta \phi}{\hat{P}^{\Delta \tau = 0}} \]

- \[ E[C | P] = \partial E[\Delta \phi | P] / \partial P \]
A Minor Note

- $\mathbb{E}[E|P] = \Pr\{E = 1|P(X,\Delta \tau) = \Pr\{U_E > P\} = P$.

- Identification requires $U_0 \perp P$. 
Estimation with Heterogeneity

\[ \Delta \varphi = \beta_0 + (\beta_1 - \beta_0)E + U_0 + (U_1 - U_0)E \]

\[ C = \beta_1 - \beta_0 + U_1 - U_0 \]

\[ \mathbb{E}[\Delta \varphi | E] = \beta_0 + (\beta_1 - \beta_0)E + \mathbb{E}[U_0 | E] + \mathbb{E}[(U_1 - U_0)E | E] \]

IV fails because \( \text{Cov}[E, \Delta \tau] < 0 \) so that the residual is correlated with the instrument.

\[ \mathbb{E}[\Delta \varphi | P] = \beta_0 + (\beta_1 - \beta_0)P + \mathbb{E}[(U_1 - U_0)E | P] \]

**Theorem 1** (*Heckman and Vytlacil, PNAS, 1999, MTE Identification*)

\[ \mathbb{E}[C | P] = \frac{\partial \mathbb{E}[\Delta \varphi | P]}{\partial P}. \]
Proof (1)

• We do not observe whether the firm has reorganized. However, in the region we are interested in $R = E = 1$. Thus,

$$\Delta \varphi \equiv \Delta \varphi_0 + E(\Delta \varphi_1 - \Delta \varphi_0).$$

• Consider a selection rule based on.

$$g(Z) > V_E$$

• Let $F_V$ be the cdf of $V$. Then the rule is equivalent to

$$F_V(Z) > F_V(V_E).$$

• Define $U_E = F_V(V_E)$. Then $U_E$ is uniformly distributed on $(0,1)$,

$$P(Z) = \Pr(E = 1|Z) = F_V(g(Z)),$$

and the distribution of $U_E$ conditional on $U_E < P(Z)$ is $1/P(Z)$. 
Proof (2)

\[ \mathbb{E}[\Delta \varphi | P(Z) = P(z)] \]

\[ = \int_0^{P(z)} \mathbb{E}[\Delta \varphi_1 | U_E \leq p] \frac{1}{P(z)} dp \cdot P(z) + \int_{P(z)}^{1} \mathbb{E}[\Delta \varphi_0 | U_E > p] \frac{1}{1 - P(z)} dp \cdot (1 - \frac{1}{P(z)}) \]

\[ = \int_0^{P(z)} \mathbb{E}[\Delta \varphi_1 | U_E \leq p] dp + \int_{P(z)}^{1} \mathbb{E}[\Delta \varphi_0 | U_E > p] dp \]

**Theorem 2** *(Heckman and Vylacil, 1999)*

\[ \mathbb{E}[C | P] = \frac{\partial \mathbb{E}[\Delta \varphi | P(Z) = P(z)]}{\partial P(z)} \]
Relationship to LATE

- **LATE:** $E [C \mid U_E \text{ is in the Switcher set}]$

  Switcher Set: $P(X, \Delta \tau = 0) < U_E < P(X, \Delta \tau = 1)$

- **MTE:** $E [C \mid U_E \text{ is on the Line}]$

  Firms on the Line: $P(X, \Delta \tau) = U_E$

- **MTE** is the limit of LATE as the Switcher interval shrinks.
Estimation

- Assume $\beta_1(x) = \beta_0(x) = \beta x$.

- $\Delta \varphi = \beta x + U_0 + (U_1 - U_0)E$.

\[ E[\Delta \varphi | P] = \beta x + E[(U_1 - U_0)E|P] \]
\[ = \beta x + E[(U_1 - U_0)|P,E = 1] \cdot P \]
\[ = \beta x + K(P) \]

- Four-Stage Procedure:

  1. Estimate a probit explaining entry $E$ on $Z = (\varphi_0, \Delta \tau) \Rightarrow \hat{P}$

  2. Local linear regression of observed productivity growth $\Delta \varphi$ on $x$ and $\hat{P} \Rightarrow \hat{K}(\hat{P})$.

  3. Differentiate $\hat{K}(\hat{P})$:

\[ \overbrace{E[C|P]} = \frac{\partial E[\Delta \varphi | P]}{\partial \hat{P}} = \frac{\partial \hat{K}(\hat{P})}{\partial \hat{P}} \]
Hypothesis Testing

- Bootstrap standard errors.
- There is heterogeneous treatment effects ($U_1 \neq U_0$) if the derivative is not a constant.
- The theory is ‘true’ if the derivative looks like the profiles from the theory.
Canada-U.S. Free Trade Agreement Timeline

• January 1, 1989: Tariff concessions begin. 1 in 4 industries faced tariffs in excess of 10%.
• December 31, 1996: Average tariff under 1%, nothing above 5%.
Canadian Exports to the United States: Little Entry Between 1984 and 1988?
The Sample

• Data on export status for 1984 and 1996.
  ► If the FTA was anticipated, we want pre-1985 data
    ⇒ 1984 baseline.
  ► If not anticipated, we want pre-1989 data
    ⇒ 1988 baseline.

• Data on the tariff concessions against each of the HS6 outputs produced by a plant. Aggregate using 1996 weights to obtain plant-specific tariff concessions $\Delta \tau'$.

• Binary tariffs.
  ► Prohibitive tariffs, fat tails, Swiss formulas, probits.
  ► $\Delta \tau = 1$ if $\Delta \tau' > \text{median (industry or all)}$.
  ► $\Delta \tau = 0$ otherwise.
The Sample (continued)

- Three types of plants:
  - ‘Nonexporters’: Did not export in 1984 or 1996 (2,133 plants)
  - ‘New Exporters’: Did not export in 1984, exported in 1996 (3,114)
  - Exported in 1984 and 1996 (4,000 plants)
Table 1. Average Plant Characteristics *After* Deviating from Industry Medians

<table>
<thead>
<tr>
<th>Variable</th>
<th>New Exporters $E = 1$</th>
<th>Nonexporters $E = 0$</th>
<th>Difference $\mu_1 - \mu_0$</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>% with Tariff Concessions</td>
<td>64%</td>
<td>34%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Log Employment, 1988</td>
<td>1.43</td>
<td>0.92</td>
<td>0.50</td>
<td>16.87</td>
</tr>
<tr>
<td>Log Productivity, 1988</td>
<td>0.48</td>
<td>0.31</td>
<td>0.17</td>
<td>9.55</td>
</tr>
<tr>
<td>Annual Log Productivity Growth 1988-96</td>
<td>1.4%</td>
<td>-0.5%</td>
<td>1.8%</td>
<td>7.32</td>
</tr>
<tr>
<td></td>
<td>Coeff.</td>
<td>Prob.</td>
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<tr>
<td>---------------------------</td>
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<tr>
<td>$\Delta \tau_{FTA}$</td>
<td>0.89</td>
<td>0.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log Productivity, 1984</td>
<td>0.26</td>
<td>0.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log Employment, 1984</td>
<td>0.36</td>
<td>0.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log Productivity Growth, 1984-88</td>
<td>0.89</td>
<td>0.000</td>
<td></td>
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<tr>
<td>SIC4 Fixed Effects</td>
<td>Yes</td>
<td></td>
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<tr>
<td>Observations</td>
<td>5,247</td>
<td></td>
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</tr>
</tbody>
</table>
The Probability of Entry Without a Tariff Concession:

\[ P(x, \Delta \tau_{FTA} = 0) = P(E = 1 \mid X = x, \Delta \tau_{FTA} = 0) \]
Ratio of Nonexporters to New Exporters
By Probability of Entry

Probability of Entry: $P(x, \Delta \tau_{FTA})$
Number of Plants by Probability of Entry

Number of Plants
Nonexporters
New Exporters

Probability of Entry: \( P( x, \Delta \tau^{FTA} ) \)

![Bar chart showing the number of plants by probability of entry for nonexporters and new exporters.](image)
Causal Effects of Improved Market Access on Productivity Growth

\[ \phi_1 - \phi_0 \]

\[ \frac{F^R + F^E}{A + \tau^{-\sigma} A^*} \]

\[ \frac{F^R}{A + \tau^{-\sigma} A^*} \]

\[ \frac{F^E}{\tau^{-\sigma} A^*} \]
Marginal Treatment Effects: 1988-96

Average Annual Change in Productivity

Probability of Entry: \( P(\tau) = \Pr( E=1 \mid x, \Delta \tau^{FTA}) \)
Marginal Treatment Effects: 1988-96
Industries with Large Tariff Cuts

Avg. Annual Change in Productivity

Probability of Entry: $P(z) = Pr(E=1 | x, \Delta\tau^{FTA})$
Marginal Treatment Effects: 1988-96
By Ownership

Probability of Entry:  \( P(z) = Pr( E = 1 \mid x, \Delta \tau^{FTA} ) \)
<table>
<thead>
<tr>
<th></th>
<th>High Productivity Plants: $P(z) &gt; 0.5$</th>
<th>Low Productivity Plants: $P(z) &lt; 0.5$</th>
<th>Double Difference (Low - High)</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product Innovation</strong></td>
<td></td>
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</tr>
<tr>
<td>New Exporters</td>
<td>Mean 0.20 t-stat 0.31</td>
<td>Mean 0.16 t-stat 3.98</td>
<td>0.14</td>
<td>542</td>
</tr>
<tr>
<td>Non-exporters</td>
<td>Mean 0.18 t-stat 0.13</td>
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<tr>
<td><strong>Design &amp; Engineering Adoption</strong></td>
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<tr>
<td>New Exporters</td>
<td>Mean 0.43 t-stat 0.35</td>
<td>Mean 0.47 t-stat 0.23</td>
<td>0.16</td>
<td>542</td>
</tr>
<tr>
<td>Non-exporters</td>
<td></td>
<td></td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td><strong>Design &amp; Engineering, Plans 93</strong></td>
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</tr>
<tr>
<td>New Exporters</td>
<td>Mean 0.23 t-stat 0.07</td>
<td>Mean 0.22 t-stat 0.08</td>
<td>0.16</td>
<td>542</td>
</tr>
<tr>
<td>Non-exporters</td>
<td></td>
<td></td>
<td>0.06</td>
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<tr>
<td><strong>Design &amp; Engineering, Plans 98</strong></td>
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</tr>
<tr>
<td>New Exporters</td>
<td>Mean 0.31 t-stat 0.44</td>
<td>Mean 0.28 t-stat 0.21</td>
<td>0.01</td>
<td>852</td>
</tr>
<tr>
<td>Non-exporters</td>
<td></td>
<td></td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td><strong>Number of commodities added, all plants</strong></td>
<td></td>
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</tr>
<tr>
<td>New Exporters</td>
<td>Mean 0.35 t-stat 0.93</td>
<td>Mean 0.27 t-stat 0.29</td>
<td>0.09</td>
<td>3,121</td>
</tr>
<tr>
<td>Non-exporters</td>
<td></td>
<td></td>
<td>0.09</td>
<td></td>
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<tr>
<td><strong>Commodity turnover index based on values of commodities</strong></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>New Exporters</td>
<td>Mean 0.06 t-stat 0.88</td>
<td>Mean 0.01 t-stat 0.01</td>
<td>0.08</td>
<td>2,140</td>
</tr>
<tr>
<td>Non-exporters</td>
<td></td>
<td></td>
<td>0.08</td>
<td></td>
</tr>
</tbody>
</table>
Table. Process Innovation and Productivity Gains

<table>
<thead>
<tr>
<th></th>
<th>High Productivity Plants: P(z) &gt; 0.5</th>
<th>Low Productivity Plants: P(z) &lt; 0.5</th>
<th>Double Difference (Low - High)</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>t-stat</td>
<td>Mean</td>
<td>t-stat</td>
</tr>
<tr>
<td>Fabrication and Assembly</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>New Exporters</td>
<td>0.33</td>
<td>0.23</td>
<td>0.23</td>
<td></td>
</tr>
<tr>
<td>Non-exporters</td>
<td>0.31</td>
<td>0.13</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>0.02</td>
<td>0.28</td>
<td>0.10</td>
<td>2.57</td>
</tr>
<tr>
<td>Infromation and Communication</td>
<td></td>
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<tr>
<td>New Exporters</td>
<td>0.46</td>
<td>0.42</td>
<td>0.42</td>
<td></td>
</tr>
<tr>
<td>Non-exporters</td>
<td>0.41</td>
<td>0.27</td>
<td>0.27</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>0.05</td>
<td>0.60</td>
<td>0.15</td>
<td>2.99</td>
</tr>
</tbody>
</table>

Table. Scale / Scope and Productivity Gains

<table>
<thead>
<tr>
<th></th>
<th>High Productivity Plants: P(z) &gt; 0.5</th>
<th>Low Productivity Plants: P(z) &lt; 0.5</th>
<th>Double Difference (Low - High)</th>
<th>N</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>t-stat</td>
<td>Mean</td>
<td>t-stat</td>
</tr>
<tr>
<td>Change in output per commodity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Exporters</td>
<td>0.31</td>
<td>1.33</td>
<td>0.43</td>
<td></td>
</tr>
<tr>
<td>Non-exporters</td>
<td>0.23</td>
<td>0.19</td>
<td>0.19</td>
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</tr>
</tbody>
</table>
Conclusions

• Improved market access matters.

• Articulating a policy-relevant question.

• With heterogeneity, traditional approaches fail:
  – RT, BJ condition on pre-entry growth
  – IV larger than OLS

• A theory of reorganization helps to explain the heterogeneity of productivity responses to increased market access.