Input Re-allocation Within Firms

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Motivation

• Trade policy and within-firm adjustment
• input-switching and output-switching for input-using firms resulting from trade shock on inputs
• E.g. within-firm reallocation of inputs and outputs
• Adjustments in within-firm markups of input-using firms
• It documents a new channel of within-firm adjustments to trade shocks
Relevant Literature

Trade Policy and Firm Exports:
- Mayer, Melitz, Ottaviano (2014)
- Bernard et al. (2011)
- Eckel and Neary (2010)

Trade Policy and Firm Imports:
- Goldberg et al. (2010)
- Gopinath and Neiman (2008)
- Kasahara and Lapham (2013)
- Bown and Tovar (2011)
- Amiti and Konings (2007)
Intuition and Theory

• An importing firm, faced with protection on inputs can:
  – Pay the import duty on the protected input
  – Switch supplier (foreign, domestic) and continue to use the input
  – Use less of the input (or stop using it)

• In all cases, the marginal cost is likely to go up

• We build a theory model predicting that such an increase in marginal cost results
Input-switching Model

The model has 3 building blocks:

i) Melitz & Ottaviano (2008) consumer preferences


iii) Halpern, Koren and Seidl (2015); Gopinath & Neiman (2008): sourcing of material inputs
Production

Production of any variety \((s)\) is given by:

\[
q(s) = A(s) L^a M^b
\]

Where \(s\): variety (firm-product), \(L\): labor input; \(A(s)\) productivity at variety level; \(M\): composite material input

\[
M = \left[ x_1 \frac{\theta-1}{\theta} + x_2 \frac{\theta-1}{\theta} \right]^{\frac{\theta}{\theta-1}}
\]
Production

The composite material input M consist of input 1, 2:

\[ M = \left[ \frac{\theta - 1}{\theta} x_1 + \frac{\theta - 1}{\theta} x_2 \right]^\frac{\theta}{\theta - 1} \]

Input 2: always sourced domestically
Input 1: sourced domestically or abroad (higher fixed cost of sourcing but lower input price)
\( \theta \): elasticity of substitution between input 1 & 2
Price of the Composite Material:

\[ p_M(p_{x_1}, p_{x_2}) = (p_{x_1}^{1-\theta} + p_{x_2}^{1-\theta})^{\frac{1}{1-\theta}} \]

Variable cost per unit of variety s:

\[ c(s) = \frac{1}{A(s)^{a+b}} \left( p_L \left[ \frac{a \cdot p_M}{b \cdot p_L} \right]^{\frac{b}{a+b}} + p_M \left[ \frac{b \cdot p_L}{a \cdot p_M} \right]^{\frac{a}{a+b}} \right) \]
Preferences

Melitz & Ottaviano (2008) quadratic utility preferences:

\[ U = \alpha \int_S q(s) ds - \frac{\beta}{2} [q(s)]^2 ds - \frac{\gamma}{2} \left[ \int_S q(s) ds \right]^2 + q_0 \]

Which results in linear demand for each variety s:

\[ p(s) = \alpha - \beta q(s) - \gamma Q \]

With Q: aggregate product market output;
\( \alpha, \beta, \gamma \): demand parameters

This gives us an equilibrium price and quantity for each variety s, as a function of marginal cost of variety \( c(s) \)
Multi-product firms

Each variety \( s \), can be considered as a variety \( i \) produced by a multi-product firm \( j \). Variety specific unit cost differs as follows:

\[
\alpha_{ji}(s) = \delta_j + \eta \cdot i
\]
Multi-product firms

Hence, each variety has a different unit cost and different unit productivity in production of $q(s)$:

$$A_{ji}(s) = \frac{1}{\alpha_{ji}(s)}$$
Sourcing

• More productive varieties will source input 1 from abroad (higher fixed cost, lower input price) (variety type m)

• Less productive varieties will source input 1 domestically (variety type n)
Trade Policy

Figure 2: Effect of trade policy on scope of type $m$ and type $n$ varieties

Scope effect: less varieties $m$ that import input 1
Theory Predictions

• **Proposition 1:** Trade protection on imported raw material inputs, results in *input reallocation* with firms using less of the protected raw material input, relative to other raw material inputs in production.

• **Proposition 2:** Trade protection on imported raw material inputs, results in *output reallocation* with firms producing less of the output affected by the protected input, relative to other outputs produced.

• **Proposition 3:** Trade protection on imported material inputs in production, results in a *decrease of markups* of affected outputs, which implies a decrease in firm-level markups for firms that import protected inputs.
Data

• Indian firm-level data with raw material inputs that a firm is using:
  – Example: Indian firm that uses “caustic soda” as an input in production (and do not produce caustic soda)

• We construct a unique input-output correspondance at firm-level

• We develop a word algorithm to match inputs in Prowess to the Global Antidumping Database (Bown, 2012)

• Trade Policy shock is at firm-input level (antidumping duties) which allows for disaggregate identification strategies

• Multi-input firms (58.5%) and multi-output firms (56%) in our data
Word Algorithm to match the data sources

**Example:**

*Bow*n database: Antidumping case on *Caustic Soda*

**Matching rule:** select input names containing *(Caust AND Sod) OR (Sod AND Hydroxid) OR (Lye AND (Sod OR Caust))*

**Prowess database:**

<table>
<thead>
<tr>
<th>Product names identified in firm-product data on raw material inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caustic Soda</td>
</tr>
<tr>
<td>Caustic Soda Flakes</td>
</tr>
<tr>
<td>Caustic Lye</td>
</tr>
<tr>
<td>Soda Ash, Caustic Soda</td>
</tr>
<tr>
<td>Sodium Hydroxide Solution</td>
</tr>
<tr>
<td>Caustic Soda</td>
</tr>
<tr>
<td>Caustic Soda Lye</td>
</tr>
<tr>
<td>Chemicals Like Caustic Soda, Sodium Silicate Etc.</td>
</tr>
</tbody>
</table>
In search of Causality

• Triple difference regressions
  – Treated: the use of treated inputs versus untreated inputs in protected firms over time
  – Untreated: the use of “treated” inputs versus untreated inputs in unprotected firms over time

• Poisson Pseudo Maximum Likelihood (PPML estimator)
  – Input value/quantities enter regression directly (and nog in logartihmic form) without zeros dropping out

• Inclusion of firm-input fixed effects
Triple Difference Regressions

Control group: non-importing firms

Example: Antidumping case on *Caustic Soda*
Example: Antidumping case on *Caustic Soda*

**Importers**
- Treated inputs used by treated firms
  - *Caustic Soda*
- Non-treated inputs used by treated firms
  - *Other inputs*

**Non-importers**
- Treated inputs used by non-treated firms
  - *Caustic Soda*
- Non-treated inputs used by non-treated firms
  - *Other inputs*

Compare *importers'* use of treated (protected) inputs vis-a-vis other inputs to *non-importers'* use of treated (protected) inputs vis-a-vis other inputs.
Trade Protection and the Intensive Margin

\[ \text{INPUT}_{ijt} = \exp \left( \beta (AD_{ijt} \times TR_{ij} \times TRFRM_i) + \gamma (AD_{ijt} \times TRFRM_i) + \phi (AD_{ijt} \times TR_{ij}) + \mu (AD_{ijt}) \right) \]

\[ + \epsilon_t + \epsilon_{ij} \right) e_{ijt}. \]

\( \text{INPUT}_{ijt} \) is value/quantity of input \( j \) used by firm \( i \) in year \( t \)

\( AD_{ijt} \) is a dummy that marks the treatment (protection) period

\( TR_{ij} \) is a dummy that marks treated inputs

\( TRFRM_i \) is a dummy that marks treated firms (i.e. importers)

\( \epsilon_t, \epsilon_{ij} \) and \( e_{ijt} \) are year fixed effect, firm-input fixed effect and error term respectively
Impact of protection and input use over time (control= non-importers)

Dependent variable: Input value

Year relative to first protection year 1

- Input switching effect in treated firms ($\phi+\beta$)
- Input switching effect in treated firms (90% confidence interval)
- Input switching effect in control firms ($\phi$)

Year 1 is the year in which protection is imposed and years on the horizontal axis are relative to that year. Year $-4$ refers to five or more years before protection is imposed. Year 7 refers to seven or more years of protection in force. Year 8 refers to years after the expiry of protection.
Extensive Margin Adjustment

Analyzes the impact of antidumping protection on the probability to add or drop an input from the input portfolio

\[
Pr(\text{drop}) = \frac{\exp(X\beta_1)}{1 + \sum_{k=1}^{2} \exp(X\beta_k)}
\]

\[
Pr(\text{add}) = \frac{\exp(X\beta_2)}{1 + \sum_{k=1}^{2} \exp(X\beta_k)}
\]

\[
Pr(\text{continue}) = \frac{1}{1 + \sum_{k=1}^{2} \exp(X\beta_k)}
\]

where

\[
X\beta_k = \beta_{0k} + \beta_{1k} PreAD_{ijt} \times TR_{ij} \times TRFRM_i + \beta_{2k} AD_{ijt} \times TR_{ij} \times TRFRM_i
+ \beta_{3k} PostAD_{ijt} \times TR_{ij} \times TRFRM_i + \beta_{4k} PreAD_{ijt} \times TRFRM_i
+ \beta_{5k} AD_{ijt} \times TRFRM_i + \beta_{6k} PostAD_{ijt} \times TRFRM_i
+ \beta_{7k} TR_{ij} \times TRFRM_i + \beta_{8k} TRFRM_i + \epsilon_{k,t}.
\]

\text{\textit{k = 1: Input dropped}}
\text{\textit{k = 2: Input added}}
Discussion of Results and Digging deeper

• strong evidence of input reallocation towards unprotected inputs
• Results hold for values, quantities of individual inputs as well as share in total
• robust to various control groups (non-importers, matched firms etc) and protection measures
• Input reallocation is permanent and remains in place after protection ends
• Results do not depend on a particular sector
• Results are stronger for large firms
• Results are stronger for multi-product firms
• Most adjustment comes through the intensive margin
• Firms do not have a higher probability to drop an input, but display a lower probability to start using an input when the input is under antidumping protection
From input-switching to output-switching

• We identify **firm-outputs** produced with **firm-inputs** under protection

• What happens on the output side after protection on inputs?
Results on output side

• Significant output reallocation

• **Output prices** of products using protected inputs **rise** on average

• This suggests some **pass-through** of higher production costs to consumers

• **Markups** fall of treated firms e.g. incomplete pass-through of rise in costs on prices
Input switching and Markups

- We use De Loecker and Warzynski (2010) to estimate firm-level markups

- Markups distribution Before and After Trade shock
Correlation of input- and output-mix

• We construct a Finger and Kreinin (1979) index of a firm’s existing input-mix and output-mix and how that changes over time

• The more similar a firm’s input and output mix from one year to another, the closer the indicators are to 1, the less dynamic the input or output mix over time

• We find a strong positive correlation of input and output dynamics in general (independent of trade policy)
Does input switching come along with output switching?

Input and output dynamics indicator:

\[ ID_{it} = \sum_{j=1}^{J_i} \min(i_{ijt}, i_{ij(t-1)}) \] and \[ OD_{it} = \sum_{k=1}^{K_i} \min(x_{ikt}, x_{ik(t-1)}) \]

*i_{ijt}* is share of firm i’s input j in total input use of year t

*x_{ikt}* is share of firm i’s output k in total output sales of year t
Input- and output-switching coinciding

\[ OD_{it} = \alpha + \beta ID_{it} + \varepsilon_i + \varepsilon_{it} \]

<table>
<thead>
<tr>
<th>Sector</th>
<th>Methodology</th>
<th>Estimate ((\beta))</th>
<th>SE</th>
<th>N</th>
<th>Firms</th>
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<td>0.016</td>
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<td>Base metals (27)</td>
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<td>0.021</td>
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Conclusion

• This paper shows that there is within-firm reallocation of inputs towards unprotected ones in response to trade policy

• Trade policy can affect firms’ input and output choice sizably

• This results in new channels of firm adjustment on trade policy.