Exchange Rate Pass-through, Firm Heterogeneity, and Product Quality

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Introduction

- This paper explores exchange rate pass-through (ERPT) at the firm level, and investigates how it depends on
  - firm heterogeneity in productivity
  - product differentiation in quality
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  - firm heterogeneity in productivity
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- Motivation
  - incompleteness of exchange rate pass-through
  - heterogeneous firm models of international trade
Literature

  \[ e \uparrow \rightarrow p \downarrow \text{(exchange rate absorption)} \rightarrow p^* = pe \uparrow < e \uparrow \]
  - \( e \): exchange rate (foreign currency/home currency).
  - \( p \): price in home currency; \( p^* \): price in foreign currency.

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- Studies at the firm level.
  - Gopinath & Rigobon (2008): incomplete ERPT


- No study on firm-level determinants (firm heterogeneity).
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Literature (ctd) and contributions

- Heterogeneous firm models:
  - feature firm hetero. in productivity; focus on intra-industry reallocation between firms due to changes in trade environment: Melitz (2003), Bernard, Eaton, Jensen, & Kortum (2003).


- ERPT depends on both firm productivity and product quality.

- Empirics: use Chinese transaction-level export data and firm-level manuf. data to test model predictions.
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The Model: Demand

- Two countries: Home \((h)\) & Foreign \((f)\), with consumers \(L^h\) & \(L^f\).

\begin{equation}
U = q_0 + \alpha \int_{i \in \Omega} (q_i + z_i) \, di - \frac{1}{2} \gamma \int_{i \in \Omega} (q_i - z_i)^2 \, di - \frac{1}{2} \eta (\int_{i \in \Omega} (q_i - \frac{1}{2} z_i) \, di)^2 \tag{1}
\end{equation}

where \(q_i\): quantity of variety \(i\); \(z_i\): quality of variety \(i\).
The Model: Demand

- Two countries: Home \((h)\) & Foreign \((f)\), with consumers \(L^h\) & \(L^f\).

- Consumers’ preferences: Antoniades (2008)

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U = q_0^c + \alpha \int_{i \in \Omega} (q_i^c + z_i) di - \frac{1}{2} \gamma \int_{i \in \Omega} (q_i^c - z_i)^2 di - \frac{1}{2} \eta \left( \int_{i \in \Omega} (q_i^c - \frac{1}{2} z_i) di \right)^2
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where \(q_i\): quantity of variety \(i\); \(z_i\): quality of variety \(i\).

- Market demand: \(l \in \{h, f\}\)

\[
q_i^l \equiv L^l q_i^c = \frac{\alpha L^l}{\eta N^l + \gamma} - \frac{L^l}{\gamma} p_i^l + \frac{\eta N^l L^l}{(\eta N^l + \gamma) \gamma} \bar{p}^l + L^l z_i^l - \frac{1}{2} \frac{\eta N^l L^l}{\eta N^l + \gamma} \bar{z}^l
\]
The Model: Supply

- Each firm in each country produces a differentiated variety, and faces a fixed entry cost $f_E$. 

$$TC_i = c_i q_i + bq_i z_i + \theta(z_i)^2$$

- A firm in the home country independently maximizes

  $$\pi_{hh} = p_{hh} q_{hh} - cq_{hh} - bq_{hh} z_{hh} - \theta(z_{hh})^2$$

  $$\pi_{hf} = p_{hf} e q_{hf} - cq_{hf} - bq_{hf} z_{hf} - \theta(z_{hf})^2$$
The Model: Supply

- Each firm in each country produces a differentiated variety, and faces a fixed entry cost $f_E$.

- Subsequent production of firm $i$ incurs the total cost function:

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  - $c_i q_i$: processing cost ($1/c_i$ indexes firm productivity)
  - $b q_i z_i$: component upgrading cost (not in Antoniades), $z_i$ market-specific
  - $\theta(z_i)^2$: R&D cost
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  \end{itemize}

- A firm in the home country independently maximizes

  $$\pi^{hh} = p^{hh} q^{hh} - c q^{hh} - b q^{hh} z^{hh} - \theta (z^{hh})^2$$

  $$\pi^{hf} = \frac{p^{hf}}{e} q^{hf} - c q^{hf} - b q^{hf} z^{hf} - \theta (z^{hf})^2$$
The Model: Equilibrium

- Equilibrium export price (in exporting currency)

\[ p = \frac{p^{hf}}{e} = (1 - B)c^{hf} + Bc. \]  

(5)

where \( B = \frac{2\gamma e - \gamma(\gamma - eb)L^f}{4\gamma e - (\gamma - eb)^2L^f} \) and \( 1 - B = \frac{2\gamma e + eb(\gamma - eb)L^f}{4\gamma e - (\gamma - eb)^2L^f} > 0 \).
The Model: Equilibrium

- Equilibrium export price (in exporting currency)

\[ p = \frac{p^{hf}}{e} = (1 - B)c^{hf} + Bc. \]  \hspace{1cm} (5)

where \( B = \frac{2\gamma \theta e - \gamma(\gamma - \varepsilon)bL_f^f}{4\gamma \theta e - (\gamma - \varepsilon)^2 L_f^f} \), and \( 1 - B = \frac{2\gamma \theta e + \varepsilon b(\gamma - \varepsilon)L_f^f}{4\gamma \theta e - (\gamma - \varepsilon)^2 L_f^f} > 0. \)

- Price-productivity schedule:

\[ \frac{\partial p}{\partial \left(\frac{1}{c}\right)} < 0 \quad \text{if} \quad B > 0, \ i.e., \ \left(\frac{2\theta}{L_f^f} + b\right) e > \gamma - \text{quality homogeneous goods} \]  \hspace{1cm} (6)

\[ \frac{\partial p}{\partial \left(\frac{1}{c}\right)} > 0 \quad \text{if} \quad B < 0, \ i.e., \ \left(\frac{2\theta}{L_f^f} + b\right) e < \gamma - \text{quality differentiated goods} \]  \hspace{1cm} (7)
The Model: Exchange Rate Absorption

- Existence of exchange rate absorption (incomplete ERPT):

\[ \frac{\partial p}{\partial e} < 0, \quad \Theta \equiv \frac{\partial p}{\partial e} e < 0 \] (exchange rate absorption elasticity) \quad (8)

\[ \rightarrow \text{due to: } \frac{\partial \mu}{\partial e} < 0 \text{ (} \mu \text{: markup), } \frac{\partial z}{\partial e} < 0 \]
The Model: Exchange Rate Absorption

- Existence of exchange rate absorption (incomplete ERPT):
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  \[ \rightarrow \text{due to: } \frac{\partial \mu}{\partial e} < 0 \text{ (\(\mu\): markup)}, \frac{\partial z}{\partial e} < 0 \]

- Absolute exchange rate absorption and productivity:
  \[ \frac{\partial |\frac{\partial p}{\partial e}|}{\partial \left(\frac{1}{e}\right)} > 0. \]  (9)
Relative exchange rate absorption and productivity

\[
\frac{\partial |\Theta|}{\partial (\frac{1}{c})} > 0 \quad \text{if} \quad B > 0, \ i.e., \ (\frac{2\theta}{Lf} + b) e > \gamma - \text{homogeneous (10)}
\]

\[
\frac{\partial |\Theta|}{\partial (\frac{1}{c})} \sim 0 \quad \text{if} \quad B < 0, \ i.e., \ (\frac{2\theta}{Lf} + b) e < \gamma - \text{differentiated (11)}
\]

\[
\frac{\partial |\Theta|}{\partial (\frac{1}{c})} < 0 \quad \text{if} \quad B \ll 0, \ i.e., \ (\frac{2\theta}{Lf} + b) e \ll \gamma - \text{differentiated (12)}
\]
Empiric: Data

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  - information included: transaction date, product (HS10), Chinese exporting/importing firms, destination/source country, value, quantity, etc.
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    - why exports: Can calculate TFP for Chinese exporting firms.
    - why to U.S.: Do not know the exact invoice currency except for transactions between China and the U.S.


Empiric: Data

- **Trade data:** Chinese transaction-level trade data collected by Chinese customs for 2000-2006.
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- **Exchange rate data:** exchange rates between Chinese RMB and the U.S. dollar for the period 2004-2006.
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Empiric: Data (ctd)

- Product quality scope:
  - Rauch classification
    - commodities: products traded on organized markets or with reference prices → quality homogeneous goods.
    - differentiated products: all other products → quality differentiated goods.

- R&D/Sales ratio for diff. industries
  - with low R&D/Sales ratios → quality homogeneous goods.
  - with mid R&D/Sales ratios → modestly differentiated goods.
  - with high R&D/Sales ratios → highly differentiated goods.

  - with short quality ladders → quality homogeneous goods.
  - with mid quality ladders → modestly differentiated goods.
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Khandelwal (2008) "quality ladders"
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Empiric: Strategies

- Test the model predictions in two different ways:
  - by pooling all products in the sample

\[
\text{lnP} \quad \text{if} \quad (t-1) = \beta \ln TFP + \delta_i (t-1) + \mu_{it}, \quad (-: \text{homogeneous}) \quad (+: \text{differentiated})
\]

\[
\Delta P_{it} = \beta_1 \Delta e_t + \beta_2 \text{TFPH}_f (t-1) + \beta_{12} [\Delta e_t \times \text{TFPH}_f (t-1)] + \delta_{it} + \mu_{it}, \quad (-)(-) (:-)
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- Test the model predictions in two different ways:
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- Test the model predictions in two different ways:
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  - by dividing all products into different groups in terms of their product quality scope.

- Pooling all products in the sample:
  - Step 1. check whether the products, on average, are quality homogeneous or differentiated goods:
    
    \[ \ln P_{if(t-1)} = \beta \ln TFP_{f(t-1)} + \delta_{i(t-1)} + \mu_{if(t-1)} \cdot (\text{− : homogeneous}) \]
    
    \[ (+: \text{differentiated}) \]  
    
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    (- : homogeneous) \\
    (+ : differentiated)
    \] (13)
  
  - Step 2. check how the absolute exchange rate absorption depends on firm productivity:
    \[
    \Delta P_{ift} = \beta_1 \Delta e_t + \beta_2 TFPH_f(t-1) + \beta_{12} [\Delta e_t \times TFPH_f(t-1)] \\
    + \delta_{it} + \mu_{ift}, \\
    \] (14)
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\]

\(- \) \((-\)  \((-\))  \((14)\)
Empiric: Strategies (ctd)

- Pooling all products in the sample (ctd)
  - Step 3. estimate exchange rate absorption elasticity:
    \[
    \Delta \ln P_{ift} = \beta \Delta \ln e_t + \delta_{it} + \mu_{ift},
    \]
    \[(-)
    \]

- Step 4. check how the relative exchange rate absorption depends on firm productivity:
  \[
  \Delta \ln P_{ift} = \beta_1 \Delta \ln e_t + \beta_2 \text{TFPH}_f(t - 1) + \beta_{12} [\Delta \ln e_t \times \text{TFPH}_f(t - 1)]
  \]
  \[(-) \quad \text{(homogeneous)} \]
  \[\quad \pm \text{(modestly differentiated)} \]
  \[\quad \text{(+ : highly differentiated)} \]
  \[\]

- Dividing all products into different groups in terms of their product quality scope (3 criteria); run regressions (13)-(16) separately for each group to test model predictions.
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Conclusions

- This paper explores the incompleteness of ERPT at the firm level, and its dependence on firm heterogeneity in productivity and product differentiation in quality.
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- On the theoretical side, I use an extended version of the Melitz and Ottaviano (2008) model and show that when exporting firms face an exchange rate change, they will absorb part of the exchange rate change by adjusting both their markups and their product quality, which leads to an incomplete exchange rate pass-through. Moreover, exchange rate absorption elasticity (in terms of its absolute value) and firm productivity are negatively correlated for products with high scope for quality differentiation, but positively correlated for quality homogeneous goods.

- On the empirical side, I will use the Chinese transaction-level export data and firm-level manufacturing data to test the model predictions.
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