Exchange Rate Exposure under Liquidity Constraints

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Financial Constraints, Firms and Aggregate Dynamics
Sophia Antipolis, France
December 15-17, 2010
Motivation

Crisis has reduced availability of external financial resources for firms (esp. SMEs)

Wide fluctuations in relative value of currencies under way

Profit sensitivity to exchange rate (exposure) gives information on firm's ability to grow in international markets.

We investigate the sensitivity of firm profits to exchange rate in presence of liquidity constraints.

We build a simple model populated by heterogeneous firms ` a la Melitz (2003) and we bring the hypotheses to the data.
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- We investigate the sensitivity of firm profits to exchange rate in presence of liquidity constraints.
- We build a simple model populated by heterogeneous firms à la Melitz (2003) and we bring the hypotheses to the data.
Outline

1. Background literature
2. Model and hypotheses
3. Econometric specification and data
4. Results
Existing literature

Exchange rate exposure literature
- Financial concerns: Muller and Verho, 2006 (for a survey)

Export and liquidity constraint literature
- Greenaway et al. (2007), Bellone et al. (2010),
- Theoretical model of Chaney (2005), Buch et al. (2010)

Our model borrows from both strands of literature. It shows that interaction between exchange rate and liquidity constraint matters both for exchange rate exposure and thus for export status too.
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Our model borrows from both strand of literature.
- It shows that interaction between exchange rate and liquidity constraint matters both for exchange rate exposure and thus for export status too.
Basic Setup

- Model populated by heterogeneous firms engaged in export activity à la Melitz (2003).
- Firms face a constant marginal cost \((ec + d)/\beta_i\) that depends on heterogeneous productivity and has an imported component.
- CES utility: 
  \[ U = \left( \int x(i)^{\sigma-1} di \right)^{\frac{\sigma}{\sigma-1}} \]
  where \(\sigma > 1\) is the elasticity of substitution.
- CES preferences yield the usual demand facing each firm: 
  \[ x_i = \frac{R p_i^{-\sigma}}{P^{1-\sigma}} \]
  ; \(R\) total expenditure.
- Price index takes the standard form 
  \[ P = \left( \int p(i)^{1-\sigma} di \right)^{\frac{1}{1-\sigma}} \]
Liquidity Constraint

- We abstract from modeling selection into exporting. Focus on exporters.
- There is a fixed cost of exporting $F$ and an iceberg transport cost $\tau > 1$.
- Fixed and variable costs need to be financed in advance.
- Each firm is endowed with an amount of liquidity $L_i$ used to incur production cost.
- Profits are given by:
  $\pi_i = \frac{e p_i x_i}{\tau} - \phi_i \left( \frac{e c + d}{\beta_i} x_i + F - L_i \right) - L_i$
  where, $e$ is the exchange rate and:

$$
\phi_i = \begin{cases} 
1 & \text{if } L_i \geq \frac{e c + d}{\beta_i} x_i + F \\
\tilde{\phi}_i > 1 & \text{if } L_i < \frac{e c + d}{\beta_i} x_i + F 
\end{cases}
$$
2. Model

Liquidity Constraint and Exchange rate

We assume Exchange Rate Shocks affect Liquidity. Exchange rate hit by a random shock:

\[ e = \bar{e} + \epsilon \]

The same shock affects firm liquidity as well:

\[ L_i = \bar{L}_i (1 + \alpha \epsilon) \]

\( \alpha \in [0,1] \) is the correlation between liquidity and aggregate shock.

Tab. 1: Effects of shocks depending on \( \alpha \):

<table>
<thead>
<tr>
<th>( \alpha &gt; 0 )</th>
<th>( \alpha &lt; 0 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depreciation</td>
<td>Increase</td>
</tr>
<tr>
<td></td>
<td>Decrease</td>
</tr>
<tr>
<td>Appreciation</td>
<td>Decrease</td>
</tr>
<tr>
<td></td>
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Eases the constraint

Heightens the constraint
Liquidity Constraint and Exchange rate

We assume Exchange Rate Shocks affect Liquidity

- Exchange rate hit by a random shock $e = \bar{e} + \varepsilon$
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- $\alpha \in [0, 1]$ is the correlation between liquidity and aggregate shock
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<tr>
<td>$\alpha &gt; 0$</td>
</tr>
<tr>
<td>monetary policy shocks</td>
</tr>
<tr>
<td>Depreciation (a positive shock) increases the liquidity eases the constraint</td>
</tr>
<tr>
<td>Appreciation (a negative shock) decreases the liquidity heightens the constraint</td>
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</tbody>
</table>

| $\alpha < 0$ |
| supply side shocks |
| Depreciation (a positive shock) decreases the liquidity heightens the constraint |
| Appreciation (a negative shock) increases the liquidity eases the constraint |
2. Model

Model Predictions on Profit Exposure

Price is markup over marginal costs:
\[ p^*_{i} = \phi_i \tau (e + d) \beta_i e \sigma - 1 \]

Export sales:
\[ x^*_{i} = R_P 1 - \sigma (\phi_i \tau (e + d) \beta_i e \sigma - 1) - \sigma if \bar{L}_i (1 + \alpha \epsilon) < e + d \beta_i x_i + F \]

Then profits are:
\[ \pi_{i} = eR\tau \sigma (p_i P) 1 - \sigma - \phi_i F + (\phi_i - 1) (\bar{L}_i (1 + \alpha \epsilon)) \]

Exposure is the sensitivity of profit to exchange rate defined as:
\[ \delta_{i} = d \pi_{i} de \]

Main result:
If liquidity depends on exchange rate, the liquidity constraint affects the profit ER exposure.
Model Predictions on Profit Exposure

- Price is markup over marginal costs: $p_i^* = \frac{\phi_i \tau (ec + d)}{\beta_i e} \frac{\sigma}{\sigma - 1}$
Model Predictions on Profit Exposure

- Price is markup over marginal costs: \( p_i^* = \frac{\phi_i \tau (ec + d)}{\beta_i e} \frac{\sigma}{\sigma - 1} \)

- Export sales: \( x_i^* = \frac{R}{p^{1-\sigma}} \left( \frac{\phi_i \tau (ec + d)}{\beta_i e} \frac{\sigma}{\sigma - 1} \right)^{-\sigma} \)
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- Export sales: \( x^*_i = \frac{R}{p^{1-\sigma}} \left( \frac{\phi_i \tau (ec + d)}{\beta_i e} \frac{\sigma}{\sigma - 1} \right)^{-\sigma} \)

- If \( \bar{L}_i (1 + \alpha \varepsilon) < \frac{ec + d}{\beta_i} x_i + F \) then profits are:
  \[
  \pi_i = \frac{eR}{\tau \sigma} \left( \frac{p_i}{P} \right)^{1-\sigma} - \phi_i F + (\phi_i - 1) \left( \bar{L}_i (1 + \alpha \varepsilon) \right)
  \]
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Model Predictions on Profit Exposure

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- Exposure is the sensitivity of profit to exchange rate defined as:
  \[ \delta_i = \frac{d\pi_i}{de} \]

Main result:

If liquidity depends on exchange rate, the liquidity constraint affects the profit ER exposure.
Model Predictions if liquidity depends on exchange rate

\[ \frac{d \pi_i}{d \beta} = \sigma - 1 \sigma R_{\beta \tau} (p_i P) \left( 1 - \sigma (\gamma + \sigma (1 - \gamma)) \right) > 0 \]

The exposure depends on financial costs:

\[ \frac{d \pi_i}{d \phi_i} = -\bar{L}_i \alpha \]

Exposure depends on the liquidity constraint in a way defined by the sign of \( \alpha \).
Model Predictions if liquidity depends on exchange rate

- Profit sensitivity is

\[
\frac{d\pi_i}{de} = \begin{cases} 
\frac{R}{\tau} \left( \frac{p_i}{P} \right)^{1-\sigma} \left[ \frac{\gamma + \sigma (1-\gamma)}{\sigma} \right] & \text{no liq. constr.} \\
\frac{R}{\tau} \left( \frac{p_i}{P} \right)^{1-\sigma} \frac{\gamma + \sigma (1-\gamma)}{\sigma} + \left( \tilde{\phi}_i - 1 \right) \bar{L}_i \alpha & \text{liq. constr.}
\end{cases}
\]
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  \end{cases}
  \]

- Profits of more productive firms are more sensitive to exchange rate shocks
  \[
  \frac{d^2\pi_i}{d\beta de} = \frac{\sigma - 1}{\sigma} \frac{R}{\beta \tau} \left( \frac{p_i}{P} \right)^{1-\sigma} (\gamma + \sigma(\gamma - 1)) > 0
  \]
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\frac{d\pi_i}{de} = \begin{cases} 
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\frac{R}{\tau} \left( \frac{p_i}{P} \right)^{1-\sigma} \left[ \frac{\gamma+\sigma(1-\gamma)}{\sigma} \right] + \left( \tilde{\phi}_i - 1 \right) \bar{L}_i \alpha & \text{liq. constr.}
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- Profits of more productive firms are more sensitive to exchange rate shocks

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\frac{d^2\pi_i}{d\theta d\epsilon} = \frac{\sigma-1}{\sigma} \frac{R}{\beta \tau} \left( \frac{p_i}{P} \right)^{1-\sigma} \left( \gamma + \sigma(\gamma - 1) \right) > 0
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- The exposure depends on financial costs: 

\[
\frac{d^2\pi_i}{d\phi_i de} = \bar{L}_i \alpha
\]
2. Model

Model Predictions if liquidity depends on exchange rate

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  \[
  \frac{d\pi_i}{d e} = \begin{cases} 
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    \frac{R}{\tau} \left( \frac{p_i}{P} \right)^{1-\sigma} \left[ \frac{\gamma + \sigma(1-\gamma)}{\sigma} \right] + \left( \phi_i - 1 \right) \bar{L}_i \alpha & \text{liq. constr.}
  \end{cases}
  \]

- Profits of more productive firms are more sensitive to exchange rate shocks
  \[
  \frac{d^2\pi_i}{d\beta d\tau} = \frac{\sigma-1}{\sigma} \frac{R}{\beta \tau} \left( \frac{p_i}{P} \right)^{1-\sigma} (\gamma + \sigma(\gamma - 1)) > 0
  \]

- The exposure depends on financial costs:
  \[
  \frac{d^2\pi_i}{d\phi_i d\tau} = \bar{L}_i \alpha
  \]

- Exposure depends on the liquidity constraint in a way defined by the sign of \(\alpha\).
Exposure depends on the liquidity constraint in a way defined by the sign of $\alpha$

$$\frac{d^2 \pi_i}{d \phi_i de} = \bar{L}_i \alpha$$

**Tab.**: Effects of FC on exposure depending on $\alpha$

<table>
<thead>
<tr>
<th></th>
<th>$\alpha &gt; 0$</th>
<th>$\alpha &lt; 0$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Depreciation</strong></td>
<td>More exposed if FC ↑</td>
<td>Less exposed if FC ↑</td>
</tr>
<tr>
<td>(a positive shock)</td>
<td>increases the liquidity</td>
<td>decreases the liquidity</td>
</tr>
<tr>
<td></td>
<td>Firms benefit more from $\epsilon &gt; 0$</td>
<td>Firms benefit less from $\epsilon &gt; 0$</td>
</tr>
<tr>
<td><strong>Appreciation</strong></td>
<td>decreases the liquidity</td>
<td>increases the liquidity</td>
</tr>
<tr>
<td>(a negative shock)</td>
<td>Firms suffer more from $\epsilon &lt; 0$</td>
<td>Firms suffer less from $\epsilon &lt; 0$</td>
</tr>
</tbody>
</table>
3. Testable Hypotheses

Testable Hypothesis

H1: Profit depends positively on exchange rate, on productivity and on liquidity; negatively on financial cost.

H2: The sensitivity of profits to exchange rate shocks grows with productivity and then with size.

H3: The sensitivity of exposure to the cost of external finance depends on the sign of the correlation between aggregate shocks and firm liquidity (i.e. the sign of $\alpha$).
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**Testable Hypothesis**

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Testable Hypothesis

$H_1$: Profit depends positively on exchange rate, on productivity and on liquidity; negatively on financial cost.

$H_2$: The sensitivity of profits to exchange rate shocks grows with productivity and then with size.
Testable Hypothesis

$H_1$: Profit depends positively on exchange rate, on productivity and on liquidity; negatively on financial cost.

$H_2$: The sensitivity of profits to exchange rate shocks grows with productivity and then with size.

$H_3$: The sensitivity of exposure to the cost of external finance depends on the sign of the correlation between aggregate shocks and firm liquidity (i.e. the sign of $\alpha$).
Data

- Data on French manufacturing firms
- Source *Enquête Annuelle d’Entreprises – EAE*: annual survey conducted by the French Ministry of Industry
- Firms with *more than 20 employees*
- Most items from the income statement plus some information from the balance sheet
- Unbalanced panel of 35,000 firms (more than 250,000 observations)
- Cover years 1995–2007
## Variable Definition

**Tab.:** Variable Definition

<table>
<thead>
<tr>
<th>Variable</th>
<th>Variable Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROFIT</td>
<td>Gross profit by firm ((E_{BE}))</td>
</tr>
<tr>
<td>EER</td>
<td>Effective Exchange rate by (isicrev3) industry</td>
</tr>
<tr>
<td>SIZE</td>
<td>Number of employees by firm</td>
</tr>
<tr>
<td>TFP</td>
<td>Total factor productivity by firm</td>
</tr>
<tr>
<td>FC</td>
<td>Interest and financial expenses over sales</td>
</tr>
<tr>
<td>LIQ</td>
<td>Cash Flows over fixed assets</td>
</tr>
<tr>
<td>(\alpha)</td>
<td>Correlation between exchange rate and liquidity by industry or year</td>
</tr>
</tbody>
</table>

*All variables are taken in logarithm in the regression.*
Specification

\[
\pi_{it} = b_0 + b_1 TFP_{it} + b_2 FC_{it} + b_3 LIQ_{it-1} + \beta_1 e_t + \beta_2 e_t \ast D_2 + \beta_3 e_t \ast D_3 + \beta_4 e_t \ast D_4 + \varepsilon_{it}
\]

where,

- \(\pi_{it}\), the log value of the firm i’s profit in year t;
- \(TPP_{it}\), the log value of the firm i’s total factor productivity in \(t - 1\);
- \(LIQ_{it-1}\), the log value of the firm i’s liquidity in t;
- \(FC_{it}\), the log of costs of external financial resources of the firm i’s in t;
- \(e_t\), the log value of the industry’s Effective ER;
- And, \(D_q\), a dummy equals to one when the firm belongs to the quartile \(q\) where \(D = \{SIZE, TFP, FC\}\).
### Results I - $H_1$ and $H_2$

<table>
<thead>
<tr>
<th></th>
<th>Dependant variable: PROFIT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SIZE</td>
</tr>
<tr>
<td>EER</td>
<td>1.918*</td>
</tr>
<tr>
<td>TFP</td>
<td>2.519*</td>
</tr>
<tr>
<td>LIQ$_{lg}$</td>
<td>0.063*</td>
</tr>
<tr>
<td>FC</td>
<td>-0.252*</td>
</tr>
<tr>
<td>eer*size2</td>
<td>0.104*</td>
</tr>
<tr>
<td>eer*size3</td>
<td>0.244*</td>
</tr>
<tr>
<td>eer*size4</td>
<td>0.566*</td>
</tr>
<tr>
<td>eer*tfp2</td>
<td></td>
</tr>
<tr>
<td>eer*tfp3</td>
<td></td>
</tr>
<tr>
<td>eer*tfp4</td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>109,210</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.658</td>
</tr>
</tbody>
</table>

* $p < 0.01$, isic.rev3 dummies included
## Results II - $H_3$ : FC Interaction and alpha

<table>
<thead>
<tr>
<th>Dependant variable : PROFIT</th>
<th>FC</th>
<th>FC $\alpha &gt; 0$</th>
<th>FC $\alpha &lt; 0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>EER</td>
<td>2.042*</td>
<td>1.505*</td>
<td>2.499*</td>
</tr>
<tr>
<td>TFP</td>
<td>1.693*</td>
<td>1.139*</td>
<td>2.392*</td>
</tr>
<tr>
<td>LIQ$_{lg}$</td>
<td>0.049*</td>
<td>0.055*</td>
<td>0.037*</td>
</tr>
<tr>
<td>FC</td>
<td>-0.248*</td>
<td>-0.242*</td>
<td>-0.239*</td>
</tr>
<tr>
<td>xrat*size2</td>
<td>0.105*</td>
<td>0.103*</td>
<td>0.108*</td>
</tr>
<tr>
<td>xrat*size3</td>
<td>0.246*</td>
<td>0.247*</td>
<td>0.246*</td>
</tr>
<tr>
<td>xrat*size4</td>
<td>0.566*</td>
<td>0.555*</td>
<td>0.570*</td>
</tr>
<tr>
<td>xrat*tfp2</td>
<td>0.013*</td>
<td>0.036*</td>
<td>-0.002</td>
</tr>
<tr>
<td>xrat*tfp3</td>
<td>0.051*</td>
<td>0.087*</td>
<td>0.027*</td>
</tr>
<tr>
<td>xrat*tfp4</td>
<td>0.126*</td>
<td>0.176*</td>
<td>0.090*</td>
</tr>
<tr>
<td>xrat*fc2</td>
<td>0.030*</td>
<td>0.032*</td>
<td>0.028*</td>
</tr>
<tr>
<td>xrat*fc3</td>
<td>0.020*</td>
<td>0.021*</td>
<td>0.018*</td>
</tr>
<tr>
<td>xrat*fc4</td>
<td>-0.001</td>
<td>0.000</td>
<td>-0.003*</td>
</tr>
<tr>
<td>Observations</td>
<td>109,210</td>
<td>41,925</td>
<td>67,164</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.671</td>
<td>0.669</td>
<td>0.682</td>
</tr>
</tbody>
</table>

*p < 0.01, isic.rev3 dummies included
Results

Results I: H₁ and H₂
Profit increases with depreciation of exchange rate. Results confirm hypothesis for size and productivity.
Higher size and higher productivity associated with higher exposure.

Results II: H₃
When $\alpha$ is negative, the exposure is lower for the quartile of firms facing the highest financial cost. When $\alpha$ is positive, we do not find a strong opposite result as expected from the model. However, results support there is an interaction between financial cost and exchange rate. More investigations on the data are needed.
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- Higher size and Higher productivity associated with higher exposure.
Results

results I : $H_1$ and $H_2$
- Profit increases with depreciation of exchange rate.
- Results confirm hypothesis for size and productivity.
- Higher size and Higher productivity associated with higher exposure.

results II : $H_3$
- When $\alpha$ is negative, the exposure is lower for the quartile of firms facing the highest financial cost.
- When $\alpha$ is positive, we do not find a strong opposite result as expected from the model.
- However, results support there is an interaction between financial cost and exchange rate. More investigations on the data are needed.
Conclusion

- We have built a model where the liquidity constraint interacts with the exchange rate.
- Empirical Results confirm that Exposure increases with size and productivity.
- Empirical Results supports the idea of an interaction between financial constraint and exchange rate to determine profit exposure (and then profit threshold to enter foreign markets).
- Empirical Results do not reject our hypothesis about the role of \( \alpha \) when the correlation is negative. The exposure is lower for the quartile of firms facing the highest financial cost: the most liquidity constrained firms benefited less from an exchange rate depreciation \((\alpha < 0)\) because the liquidity decreases with the depreciation.