International Banks and the Cross-Border Transmission of Business Cycles

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Federal Reserve Board

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1These slides and associated remarks represent only the authors’ current opinions, not those of the Board of Governors or the Federal Reserve System.
Motivation

- Disruptions in credit markets in 2007 led the Fed and other central banks to implement non-conventional policies (for example, the Term Auction Facility).

- Important involvement of large U.S. and European banks – global banks.

- Relevant role of funding via the interbank market and cross-border intrabank transactions through foreign bank branches.

- Foreign bank branches: 20 percent of all assets held by commercial banks in the United States in 2008.
Objective

Objectives:

- Study the link between the cross-border funding activities of global banks and the international transmission of business cycles.
- Highlight the effects of regulatory changes on global banks’ ability to transform domestic deposits into loans abroad.

Methodology:

1. Empirical analysis
   - Cyclical behavior of net positions between the U.S.-based branches of foreign banks (Western Europe, emerging Asia) and their parent banks (novel dataset).
   - The pattern of lending by U.S.-based subsidiaries of foreign banks to large and small U.S. firms.

2. Model
   - Two-country DSGE framework with global banks (that can transform foreign deposits into local loans) and heterogeneous firms.
Related Literature

- **Bank funding and liquidity management**: CGFS (2010), Canales-Kriljenko, Coulibaly and Kamil (2010), McGuire and von Peter (2009), Cetorelli and Goldberg (2011)


- **DSGE models with heterogeneous agents**: Ghironi and Melitz (2005)

- **Firm financing**: Neumeyer and Perri (2005), Russ and Valderrama (2009)
Data

- Branches of foreign banks in the United States: FFIEC 002 report.

- Subsidiaries of foreign banks in the United States: FFIEC 031 report.

- Macro data:
  - INTL/CEIC (real GDP growth);
  - Federal Reserve System (effective FF rate);
  - International Financial Statistics.

- "Net due to" position relative to related depository institutions (for example, relative to the parent bank) =

  = Gross due to related depository institutions (liability of the branch) –

  – Gross due from related depository institutions (asset of the branch)
### Stylized Fact 1 - Balance Sheet of U.S. branches of European banks

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash</td>
<td>4%</td>
<td>11%</td>
<td>39%</td>
<td>Deposits</td>
<td>53%</td>
<td>52%</td>
<td>52%</td>
</tr>
<tr>
<td>Fed Funds Sold</td>
<td>1%</td>
<td>0%</td>
<td>0%</td>
<td>Fed Funds Purchased</td>
<td>6%</td>
<td>1%</td>
<td>2%</td>
</tr>
<tr>
<td>Resale Agreements</td>
<td>15%</td>
<td>3%</td>
<td>5%</td>
<td>Repurchase Agreements</td>
<td>8%</td>
<td>3%</td>
<td>5%</td>
</tr>
<tr>
<td>U.S. Gov. Securities</td>
<td>2%</td>
<td>2%</td>
<td>4%</td>
<td>Trading Liabilities</td>
<td>6%</td>
<td>9%</td>
<td>5%</td>
</tr>
<tr>
<td>Other Securities</td>
<td>21%</td>
<td>25%</td>
<td>13%</td>
<td>Other Liabilities</td>
<td>18%</td>
<td>30%</td>
<td>17%</td>
</tr>
<tr>
<td>Loans</td>
<td>24%</td>
<td>27%</td>
<td>22%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Assets</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Claims on Non-Related Parties</strong></td>
<td>69%</td>
<td>70%</td>
<td>85%</td>
<td><strong>Total Liabilities to Non-Related Parties</strong></td>
<td>91%</td>
<td>95%</td>
<td>81%</td>
</tr>
<tr>
<td>Net Due from Related Depository Institutions</td>
<td>31%</td>
<td>30%</td>
<td>15%</td>
<td>Net Due to Related Depository Institutions</td>
<td>9%</td>
<td>5%</td>
<td>19%</td>
</tr>
<tr>
<td><strong>Total Assets ($ millions)</strong></td>
<td>1,193,532</td>
<td>1,402,416</td>
<td>1,328,310</td>
<td><strong>Total Liabilities ($ millions)</strong></td>
<td>1,193,532</td>
<td>1,402,416</td>
<td>1,328,310</td>
</tr>
</tbody>
</table>
Stylized Fact 1 - Net positions and macro factors (U.S. branches of European banks)

Aggregate net due to positions (with non-U.S. offices) of U.S. branches of European banks (% of assets)
Stylized Fact 1 - Net positions and macro factors (U.S. branches of European banks)

\[
\frac{NDT_{ijt}}{TA_{ijt}} = \alpha + \beta_1 \text{US GDP Growth}_t + \beta_2 \text{Foreign GDP Growth}_t + \\
+ \beta_3 \text{Real Interest Rate Differential}_t + \beta_4 \text{Log Assets}_{ijt} + \\
+ \theta_{ij} + \mu_q + \varphi_t + \epsilon_{ijt}
\]

- Bank branch \(i\), country of origin \(j\);
- \(\mu_q\) = seasonal quarterly dummy;
- \(\theta_{ij}\) = bank fixed effect
- \(\varphi_t\) = time fixed effect
Stylized Fact 1 - Net positions and macro factors (U.S. branches of European banks)

<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>Net due to / Assets</th>
<th>Gross due to / Assets</th>
<th>Gross due from / Assets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>U.S. GDP Growth</td>
<td>1.167**</td>
<td>-0.106</td>
<td>-1.273***</td>
</tr>
<tr>
<td></td>
<td>[0.536]</td>
<td>[0.326]</td>
<td>[0.342]</td>
</tr>
<tr>
<td>Foreign GDP Growth</td>
<td>0.029</td>
<td>0.024</td>
<td>-0.005</td>
</tr>
<tr>
<td></td>
<td>[0.124]</td>
<td>[0.073]</td>
<td>[0.083]</td>
</tr>
<tr>
<td>Real Interest Rate Differential</td>
<td>-1.377</td>
<td>-1.218*</td>
<td>0.159</td>
</tr>
<tr>
<td></td>
<td>[1.019]</td>
<td>[0.662]</td>
<td>[0.557]</td>
</tr>
<tr>
<td>Log of Claims on Nonrelated Parties</td>
<td>3.852</td>
<td>-2.106</td>
<td>-5.958***</td>
</tr>
<tr>
<td></td>
<td>[2.443]</td>
<td>[1.416]</td>
<td>[1.281]</td>
</tr>
<tr>
<td>Constant</td>
<td>-41.740**</td>
<td>50.994***</td>
<td>92.734***</td>
</tr>
<tr>
<td></td>
<td>[20.651]</td>
<td>[12.018]</td>
<td>[10.844]</td>
</tr>
<tr>
<td>Branch Fixed Effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Time Fixed Effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Quarterly Dummies</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Observations: 4,514 4,514 4,514
Number of Branches: 136 136 136

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1
Stylized Fact 2 - Firm size and bank lending – Domestic vs. foreign banks

![Graph showing mean share of small business loans in total number]
Model Assumptions

- Two-country (Home and Foreign), RBC model with:
  - (1) One representative household that provides bank deposits.
  - (2) Continuum of monopolistically-competitive firms, heterogeneous in productivity, borrow working capital from banks.
  - (3) Two types of banks in each country: local and global.

- The global bank, in addition to domestic operations, also collects foreign deposits and issues loans to foreign firms.

- Production by heterogeneous firms:
  - function of labor, country-specific, and firm-specific productivity.

- Each firm can borrow either from the local or from the global banks:
  - Borrowing from the global banks has the advantage of a lower interest rate, but requires a per-period fixed cost.
  - Only the larger, more productive firms access international loans; their fraction changes over time.
Model Assumptions

The "Home" economy

- **Home household**
  - Deposits to **Home "local" bank**
  - Loans to "Less productive" home firms

- **Home "global" bank**
  - Loans to "More productive" home firms

- **Foreign household**
  - Deposits to **Foreign "global" bank**
  - Loans to "More productive" foreign firms

- **Foreign "local" bank**
  - Loans to "Less productive" foreign firms

The diagram illustrates the flow of deposits and loans between the different entities within the "Home" economy.
Representative household

- Maximize expected lifetime utility:

\[
\max_{\{D_t, x_t\}} \left[ E_t \sum_{s=t}^{\infty} \beta^{s-t} \frac{C_s^{1-\gamma}}{1-\gamma} \right],
\]

- subject to:

\[
(\tilde{v}_t + \tilde{\pi}_t) N_t x_{t-1} + (1+r_t) D_{t-1} + w_t L \geq \tilde{v}_t (N_t + N_{E,t}) x_t + D_t + \frac{\xi}{2} (D_t)^2 + C_t
\]

- FOCs:

\[
1 + \xi D_t = \beta E_t \left[ (1 + r_{t+1}) \left( \frac{C_{t+1}}{C_t} \right)^{-\gamma} \right],
\]

\[
\tilde{v}_t = \beta (1 - \delta) E_t \left[ \left( \frac{C_{t+1}}{C_t} \right)^{-\gamma} (\tilde{v}_{t+1} + \tilde{\pi}_{t+1}) \right].
\]

- Consumption basket $C_t$ is a CES aggregate of country-specific goods (described later).
Firms: production

- Following entry, each firm draws productivity factor $z$ from a common distribution $G(z)$ with support on $[z_{min}, \infty)$;

Production:

$$y_t(z) = Z_t zn_t(z), \text{ with unit cost } \frac{W_t}{Z_t z}$$

- Firms must pay fraction $\phi$ of the wage bill before producing.

- Need working capital - two choices:
  - (1) Borrow from the local bank;
  - (2) Use an aggregate loan provided by the global banks (home and foreign).
(1) Firms borrowing from local banks

- Profit maximization:

\[ \pi_{L,t}(z) = \underbrace{p_{L,t}(z)y_t(z)}_{\text{revenue}} - \underbrace{w_t n_t(z)}_{\text{wage bill}} - \underbrace{r_{L,t} l_t(z)}_{\text{borrowing cost}} \]

- subject to:

\[ y_t(z) = p_{L,t}(z)^{-\theta} C_t, \]
\[ l_t(z) \geq \phi \frac{w_t}{Z_t z} y_t(z). \]

- Equilibrium price and profit:

\[ p_{L,t}(z) = \frac{\theta}{\theta - 1} \frac{w_t}{Z_t z} (1 + \phi r_{L,t}); \]
\[ \pi_{L,t}(z) = \frac{1}{\theta} p_{L,t}(z)^{1-\theta} C_t. \]
(2) Firms borrowing from global banks

- Profit maximization:

\[ \pi_{G,t}(z) = p_{G,t}(z)y_t(z) - w_t n_t(z) - r_{S,t} l_t(z) - f_G \frac{w_t}{Z_t}. \]

- subject to:

\[ y_t(z) = p_{G,t}(z)^{-\theta} C_t, \]
\[ l_t(z) \geq \phi \frac{w_t}{Z_t z} y_t(z). \]

- Equilibrium price and profit:

\[ p_{G,t}(z) = \frac{\theta}{\theta - 1} \frac{w_t}{Z_t z} (1 + \phi r_{S,t}). \]
\[ \pi_{G,t}(z) = \frac{1}{\theta} p_{G,t}(z)^{1-\theta} C_t - f_G \frac{w_t}{Z_t}. \]
Firms: endogenous productivity cutoff

- Write the firm profits as functions of productivity factor $z^{\theta-1}$:
  \[
  \pi_{L,t}(z) = \frac{1}{\theta} \left[ \frac{\theta}{\theta - 1} \frac{w_t}{Z_t} (1 + \phi r_{L,t}) \right]^{1-\theta} C_t z^{\theta-1},
  \]
  \[
  \pi_{G,t}(z) = \frac{1}{\theta} \left[ \frac{\theta}{\theta - 1} \frac{w_t}{Z_t} (1 + \phi r_{S,t}) \right]^{1-\theta} C_t z^{\theta-1} - f_G \frac{w_t}{Z_t}.
  \]

- For $r_{S,t} < r_{L,t}$, define cutoff $z_{C,t} = \{z \mid \pi_{L,t}(z) = \pi_{G,t}(z)\}$. 
Firms: aggregation

- Define average labor productivity for local borrowers ($\tilde{Z}_{L,t}$) and global borrowers ($\tilde{Z}_{G,t}$):

- Every period, $N_{L,t}$ firms borrow locally ($z < z_{C,t}$), and $N_{G,t}$ firms borrow from the global banks ($z > z_{C,t}$);

- So that $N_{L,t} + N_{G,t} = N_t$. 
Pareto-distributed firm productivity

- Firm-specific labor productivity $z$ is Pareto-distributed:

$$g(z) = k z_{min}/z^{k+1}$$
$$G(z) = 1 - (z_{min}/z)^k.$$ 

- Under the Pareto assumption, the firm productivity averages are:

$$\tilde{Z}_{L,t} = \left[ \frac{1}{G(z_{C,t})} \int_{z_{min}}^{z_{C,t}} z^{\theta-1} g(z) dz \right]^{\frac{1}{\theta-1}} = \nu z_{min} z_{C,t} \left[ \frac{z_{C,t}^{k-(\theta-1)} - z_{min}^{k-(\theta-1)}}{z_{C,t}^{k} - z_{min}^{k}} \right]^{\frac{1}{\theta-1}},$$

$$\tilde{Z}_{G,t} = \left[ \frac{1}{1-G(z_{C,t})} \int_{z_{C,t}}^{\infty} z^{\theta-1} g(z) dz \right]^{\frac{1}{\theta-1}} = \nu z_{C,t}.$$
Firms: aggregation

- Average prices:
  \[ \tilde{p}_{L,t} = \frac{\theta}{\theta - 1} \frac{w_t}{Z_t \tilde{z}_{L,t}} (1 + \phi r_{L,t}) \]  
  (local borrowing)
  \[ \tilde{p}_{G,t} = \frac{\theta}{\theta - 1} \frac{w_t}{Z_t \tilde{z}_{G,t}} (1 + \phi r_{S,t}) \]  
  (global borrowing)

- Average profits:
  \[ \tilde{\pi}_{L,t} = \frac{1}{\theta} (\tilde{p}_{L,t})^{1-\theta} C_t \]  
  (local borrowing)
  \[ \tilde{\pi}_{G,t} = \frac{1}{\theta} (\tilde{p}_{G,t})^{1-\theta} C_t - f_G \frac{w_t}{Z_t} \]  
  (global borrowing)

- Price index:
  \[ N_t (p_{h,t})^{1-\theta} = N_{L,t} (\tilde{p}_{L,t})^{1-\theta} + N_{G,t} (\tilde{p}_{G,t})^{1-\theta} \]
  \[ N_t^* (p_{f,t})^{1-\theta} = N_{L,t}^* (\tilde{p}_{L,t}^*)^{1-\theta} + N_{G,t}^* (\tilde{p}_{G,t}^*)^{1-\theta} \]

- Total profits:
  \[ N_t \tilde{\pi}_t = N_{L,t} \tilde{\pi}_{L,t} + N_{G,t} \tilde{\pi}_{G,t} \]
  \[ N_t^* \tilde{\pi}_t^* = N_{L,t}^* \tilde{\pi}_{L,t}^* + N_{G,t}^* \tilde{\pi}_{G,t}^* \]
Country-specific goods and trade

Production

- Each firm produces variety $y_t(\omega)$.
- All varieties $\omega$ available at period $t$ form the country-specific good:

$$\hat{Y}_{h,t} = \left[ \int_{\omega \in \Omega} y_t(\omega) \frac{\theta-1}{\theta} d\omega \right]^{\frac{\theta}{\theta-1}},$$

where $\theta > 1$ is the elasticity of substitution across varieties.

Trade

- The home-specific good $\hat{Y}_{h,t}$ can be consumed domestically ($Y_{h,t}$) or exported ($Y_{h,*}$), so that $\hat{Y}_{h,t} = Y_{h,t} + Y_{h,*}$.

Prices

- The home consumption basket $C_t$ is a CES aggregate of the home and foreign-specific goods, set as the numeraire ($P_t = 1$):

$$C_t = \left[ \left( \lambda_y \right)^{\frac{1}{\varepsilon_y}} (Y_{h,t})^{\frac{\varepsilon_y-1}{\varepsilon_y}} + (1 - \lambda_y) \left( Y_{f,t} \right)^{\frac{\varepsilon_y-1}{\varepsilon_y}} \right]^{\frac{\varepsilon_y}{\varepsilon_y-1}}.$$
In each economy, two types of banks (local and global) transform deposits into loans, as in de Blas and Russ (2010):

\[ L_{j,t} = \frac{D_{j,t}}{c_j}, \text{ where } c_j \geq 1 \text{ and } j \in \{L, G\}. \]

The global bank is more productive \((c^G < c^L)\), so that \(r^G < r^L\).

1. **The local bank**
   - Profit: \(\Omega_{L,t} = r_{L,t}(1 - \delta)L_{L,t} - \mu \delta L_{L,t} - r_tD_{L,t-1} = 0.\)
     - Interest received for good loans
     - Monitoring cost for non-performing loans
     - Interest paid on deposits
   - The cost \(c\) and firm exit \(\delta\) introduce a wedge between \(r_t\) and \(r_{L,t}\):
     \[ r_{L,t} = \frac{c^L}{1 - \delta} r_t + \frac{\mu \delta}{1 - \delta}. \]
   - Loan clearing: \(L_{L,t} = N_{L,t}\tilde{I}_{L,t}\), where
     \[ \tilde{I}_{L,t} = \frac{\phi w_t}{Z_t z_L,t} \left( \frac{\rho_{L,t}}{\rho_{h,t}} \right)^{-\theta} \left( Y_{h,t} + Y_{h,t}^* \right). \]
(2) The global bank

- Interest charged for loans is a weighted average of the cost of home and foreign deposits:

\[
 r_{G,t} = \frac{D_{H,t-1}}{D_{H,t-1} + D_{H,t-1}^*} \left( \frac{c_G r_t + \mu \delta}{1 - \delta} \right) + \frac{D_{H,t-1}^* Q_t}{D_{H,t-1} + D_{H,t-1}^*} \left( \frac{c_G r^*_t Q_t + \mu \delta}{1 - \delta} \right)
\]

- Market clearing for the global loans:

\[
 L_{S,t} = \left[ \lambda^{\frac{1}{\epsilon}} L_{H,t}^{\frac{e-1}{\epsilon}} + (1 - \lambda)^{\frac{1}{\epsilon}} L_{F,t}^{\frac{e-1}{\epsilon}} \right]^{\frac{\epsilon}{e-1}} = N_{G,t} \tilde{I}_{G,t}.
\]

Allocation of deposits

- Home deposits $D_{t-1}$ are allocated in fixed shares across the home local, home global, and foreign global banks: $S_L + S_H + S_F = 1$.

Bank lending constraints

\[
 L_{H,t} + L_{H,t}^* Q_t = \frac{S_H D_{t-1} + S_H^* D_{t-1}^* Q_t}{c_G} \quad \text{and} \quad L_{F,t} + \frac{L_{F,t}^*}{Q_t} = \frac{S_F^* D_{t-1}^* + S_F D_{t-1}^*}{c_G^*}.
\]
Closing the model

- Net lending (Net Due To Position) by foreign branches in Home:

\[ NDTP^*_t = \frac{1}{Q_t} \left[ L_{F,t} - \frac{S_F D_{t-1}}{c_G^*} \right]. \]

- Net lending by home branches abroad:

\[ NDTP_t = Q_t \left[ L_{H,t}^* - \frac{S_H^* D_{t-1}^*}{c_G} \right]. \]

- The balance of payments equation:

\[
\begin{aligned}
&\underbrace{p_{h,t} Y_{h,t}^* - p_{f,t} Q_t Y_{f,t}}_{\text{net exports}} + \underbrace{r_t S_F D_{t-1} - r_t^* S_H^* D_{t-1}^* Q_t}_{\text{net interest payments}} \\
= &\underbrace{S_F (D_t - D_{t-1}) - S_H^* (D_t^* - D_{t-1}^*)}_{\text{change in stock of foreign assets}}.
\end{aligned}
\]
# Calibration

- **Standard quarterly calibration:**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \beta )</td>
<td>0.99</td>
<td>Discount factor</td>
</tr>
<tr>
<td>( \gamma )</td>
<td>2</td>
<td>CRRA coefficient</td>
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<tr>
<td>( \theta )</td>
<td>3.8</td>
<td>Intra-temporal elasticity of substitution</td>
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<tr>
<td>( f_E )</td>
<td>1</td>
<td>Firm’s sunk entry cost</td>
</tr>
<tr>
<td>( k )</td>
<td>3.4</td>
<td>Pareto distribution parameter</td>
</tr>
<tr>
<td>( \delta )</td>
<td>0.025</td>
<td>Probability of firm exit</td>
</tr>
<tr>
<td>( \phi )</td>
<td>0.5</td>
<td>Share of wage bill to be financed</td>
</tr>
<tr>
<td>( f_G )</td>
<td>0.0002</td>
<td>Firms’ fixed cost for global loans</td>
</tr>
<tr>
<td>( C_L )</td>
<td>1.05, ( C_G )</td>
<td>1.01</td>
</tr>
<tr>
<td>( S_L )</td>
<td>0.4, ( S_H )</td>
<td>0.3, ( S_F )</td>
</tr>
<tr>
<td>( \mu )</td>
<td>0.01</td>
<td>Banks’ monitoring cost</td>
</tr>
<tr>
<td>( \varepsilon \lambda )</td>
<td>1.4</td>
<td>Substitution, home and foreign loans</td>
</tr>
<tr>
<td>( \lambda )</td>
<td>0.5</td>
<td>Share of home global bank in syndicate</td>
</tr>
</tbody>
</table>

- **Steady state:** 1% of firms borrow globally, account for 9% of total borrowing; foreign banks provide 5% of total lending.
Impulse responses

- % deviations from steady state, (+) TFP shock in Home ($\rho = 0.9$):
Further work

- Study the model dynamics in response to shocks:
  - A positive TFP shock in Home:
    → firms’ ability to access foreign deposits amplifies the expansion;
    → as more of the small firms gain access to international loans → further amplification.
  - A negative TFP shock in Home:
    → international bank lending exacerbates the contraction.

- Analyze the implications of proposed Basel III liquidity standards that would decrease the amount of intrabank funding:
  - Limit banks’ ability to use deposits from one country to make loans in another.
Stylized Fact 2 - Firm size and bank lending – Domestic vs. foreign banks

![Graph showing the mean share of small business loans in total value](image-url)
Stylized facts - Net positions and macro factors (U.S. branches of Asian banks)

Aggregation net due to positions (with non-U.S. offices) of U.S. branches of emerging Asian banks (% of assets)
Stylized facts - Net positions and the demand for dollar funding

Aggregate net due to positions (with non-U.S. offices) of U.S. branches of TAF borrowers
### Stylized facts - Net positions and the demand for dollar funding

<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>Net due to / Assets (1)</th>
<th>Gross due to / Assets (2)</th>
<th>Gross due from / Assets (3)</th>
<th>Net due to / Assets (4)</th>
<th>Gross due to / Assets (5)</th>
<th>Gross due from / Assets (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dummy Crisis</td>
<td>3.086</td>
<td>4.072*</td>
<td>0.986</td>
<td>3.692**</td>
<td>4.366***</td>
<td>0.674</td>
</tr>
<tr>
<td></td>
<td>[2.574]</td>
<td>[2.367]</td>
<td>[1.313]</td>
<td>[1.489]</td>
<td>[1.474]</td>
<td>[0.663]</td>
</tr>
<tr>
<td>Dummy Europe</td>
<td>-23.298***</td>
<td>-14.067***</td>
<td>9.231***</td>
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Robust standard errors in brackets

*** p<0.01, ** p<0.05, * p<0.1
Firm Entry with Sunk Costs

Firm entry

- Firm entry takes place until the sunk entry cost equals the net present value of the average firm, as in Ghironi and Melitz (QJE, 2005):

\[ f_E \frac{w_t}{Z_t} = \tilde{v}_t, \]

where:

\[ \tilde{v}_t = E_t \sum_{s=t+1}^{\infty} [\beta(1 - \delta)]^{s-t} \left( \frac{C_s}{C_t} \right)^{-\gamma} \tilde{\pi}_s. \]

- The law of motion for the number of producing firms is:

\[ N_{t+1} = (1 - \delta)(N_t + N_{E,t}). \]
Calibration exercise

- Vary the fixed cost $f_G$ of international borrowing: