Sovereign Default Risk and Firm Heterogeneity

Cristina Arellano
Federal Reserve Bank of Minneapolis

Yan Bai
University of Rochester and NBER

Luigi Bocola
Stanford University and NBER

UCL
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Motivation

• Government debt crises are typically associated to deep recessions
  • E.g. Southern Europe in 2010-2012

• Why negative relation between sovereign risk and economic activity? Two mechanisms in the literature:
  1 Gov’t defaults in bad times $\rightarrow$ Risk of default reflects deterioration of economic fundamentals (Arellano, 2008; Aguiar and Gopinath, 2006)
  2 Banks hold Gov’t debt $\rightarrow$ Negative balance sheet effects when sovereign risk increases (Gennaioli, Martin and Rossi, 2014; Bocola, 2016)

• Important to quantify these mechanisms
  • Debate on fiscal austerity during Eurozone crisis
Measuring aggregate implications of sovereign risk

- Two main approaches to measure aggregate effects of sovereign risk
  - Structural models, fit to aggregate data
    - **Drawback**: measurement often not transparent
  - Difference-in-differences estimates with firm-bank level data
    - **Drawback**: not designed to capture aggregate effects

- Our paper aims to combine these two approaches
  - Model of Gov’t debt crisis with heterogeneous firms and banks
  - Discipline model with aggregate *and* micro data
Our Approach

- Sovereign debt model with financial intermediation and production
  - Gov’t affects private sector through impact on banks’ balance sheet
  - Firms differ in borrowing needs, banks in exposure to Gov’t debt
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• Effects of sovereign risk are heterogeneous across firms
  • Direct effect, working through firms’ borrowing costs
    • Stronger for firms that borrow more/borrow from exposed banks
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  • Direct effect, working through firms’ borrowing costs
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  • Indirect effects, working through demand of goods and labor
    • Affects all firms irrespective of whether they borrow or not
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  - Indirect effects, working through demand of goods and labor
    - Affects all firms irrespective of whether they borrow or not

- Show that direct effect is identified from firm/bank level data
  - Difference-in-difference-in-differences (DDD): compare response to sovereign risk between firms with different borrowing needs across banks with different sovereign debt exposure
Main Results

- Estimate DDD using Italian firm and bank level data (Amadeus and Bankscope)
  - Larger decline for highly levered firms during sovereign crisis, more so if borrow from banks with high sovereign debt exposure

- Fit structural model to firm, bank and aggregate data
  - Infer size/sign of indirect effects

- Use model to interpret the recent crisis
  - 100bp of sovereign spreads leads to 60bp increase in firms’ cost of funds and 0.8% fall in GDP
  - Gov’t debt crisis accounts for ≈ 1/3 of output decline
  - Mostly due to direct effect
Outline

1 Model

2 Mechanisms and Measurement

3 Empirical Analysis

4 Quantitative Analysis
Model

- Central Government finances expenditure in public goods
  - Taxes firms ($\tau$) and borrow long-term from banks ($\vartheta$)
  - Can default on debt

- $J$ regions with firms, families, and financial intermediaries
  - Firms produce, face working capital constraints
  - Intermediaries lend to firms and Gov’t, face leverage constraints

- Two key sources of heterogeneity
  - Firms differ in working capital requirements. Intermediaries differ in holdings of Gov’t debt

- Two aggregate shocks
  - Firms’ productivity
  - Government default costs ($\nu$)
Firms

Local labor, financial and intermediate goods markets in each region

1. **Final goods firms**: perfectly competitive, use intermediates to produce

\[
Y_{jt} = \left( \int y_{jt}(i)^\eta di \right)^{\frac{1}{\eta}}
\]

2. **Intermediate good firms**: Produce with capital and labor under monopolistic competition

\[
y_{ijt} = \exp\{\tilde{z}_{ijt}\}(k_{ijt}^{\alpha} \ell_{ijt}^{1-\alpha})
\]

- Finance \(\lambda_i\) of input costs with loan \(b_{ijt}\) at rate \(R_{jt}\)

\[
b_{ijt}^f = \lambda_i (r_{jt}^k k_{ijt} + w_{jt} \ell_{ijt})
\]

- Firm productivity has idiosyncratic and aggregate component

\[
\tilde{z}_{ijt} = A_t + z_{ijt}
\]

where \(A_t\) and \(z_{ijt}\) are independent Gaussian AR(1)
Families

- Families consists of workers and bankers

- Decide consumption $C_{jt}$, capital $K_{jt}$, deposits $A_{jt}$ and labor $L_{jt}$ to maximize

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left( C_{jt} - \chi \frac{L_{jt}^{1+\gamma}}{1 + \gamma} \right)$$

- Bankers run financial intermediaries for two periods
  - Receive transfer from own family
    $$N_{jt} = \bar{n}_j + (1 - D_t)(1 - \vartheta)q_t B_{jt}$$
  - $(\bar{n}_j, B_{jt})$ only degree of heterogeneity across regions
Financial Intermediaries

• Issue deposits \((A_{jt})\), invest in Gov’t and firms bonds \((B_{jt}, \{b_{ijt}^f\})\)

\[
\max_{A_{jt}, B_{jt+1}, \{b_{ijt}^f\}} \beta E_t \left\{ (1 - D_{t+1}) \left[ \vartheta B_{jt+1} + q_{t+1} (1 - \vartheta) B_{jt+1} \right] + \right.
\]
\[
+ R_{jt} \int b_{ijt}^f d\hat{t} - A_{jt} \right\}
\]

• Balance sheet and financial constraint

\[
q_t B_{jt+1} + \int b_{ijt}^f d\hat{t} \leq N_{jt} + q_{jt}^a A_{jt}
\]

\[
q_{jt}^a A_{jt} \leq \theta \int b_{ijt}^f d\hat{t} + q_t B_{jt+1}
\]
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\]
\[
\left. + R_{jt} \int b_{ijt}^{f} di - A_{jt} \right\}
\]

- Balance sheet and financial constraint

\[
q_{t} B_{jt+1} + \int b_{ijt}^{f} di \leq N_{jt} + q_{jt}^{a} A_{jt}
\]
\[
\int b_{ijt}^{f} di \leq \frac{N_{jt}}{1 - \theta} \quad (\zeta_{jt})
\]
Financial Intermediaries

- Issue deposits \((A_{jt})\), invest in Gov’t and firms bonds \((B_{jt}, \{b_{ijt}^f\})\)

\[
\max_{A_{jt}, B_{jt+1}, \{b_{ijt}^f\}} \beta E_t \left\{ (1 - D_{t+1}) [\vartheta B_{jt+1} + q_{t+1}(1 - \vartheta)B_{jt+1}] + R_{jt} \int b_{ijt}^f di - A_{jt} \right\}
\]

- Balance sheet and financial constraint

\[
q_t B_{jt+1} + \int b_{ijt}^f di \leq N_{jt} + q_{jt}^{\alpha} A_{jt}
\]
\[
\int b_{ijt}^f di \leq \frac{N_{jt}}{1 - \theta} \quad (\zeta_{jt})
\]

- Euler equations

\[
R_{jt} = \frac{1 + \zeta_{jt}}{\beta}
\]
\[
q_t = \mathbb{E}_t \{ \beta [(1 - D_{t+1}) (\vartheta + q_{t+1}(1 - \vartheta))] \}
\]
Equilibrium

Aggregate state $s = (A, \nu, B)$. Given Gov’t policies ($B', D$), a private sector equilibrium is such that

- Firms, families, and financial intermediaries optimize
- Labor, goods, capital, deposits, bond and loan markets clear
Equilibrium

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- Focus on private sector equilibrium where $B'_j = \varphi_j B'$
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Given $Y^a(s, D, B')$, Gov’t policies solve recursive problem

- Default decision
  \[
  W(s) = \max_{D = \{0, 1\}} \{ (1 - D) V(s) + D [V(A, \nu, 0) - \nu] \}
  \]

- The value of repaying solves
  \[
  V(s) = \max_{B'} u_g(G) + \beta_g \mathbb{E} W(s')
  \]
  \[
  G + \vartheta B = \tau Y^a(s, D, B') + q(s, B') [B' - (1 - \vartheta) B]
  \]
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The Private Sector Equilibrium

The state variables for the private sector equilibrium are \( X_j = [A, N_j] \)

**Lemma 1.** In a private sector equilibrium, \( R_j \geq \frac{1}{\beta} \) solves

\[
\frac{N_j}{(1 - \theta)} \geq M_n \lambda(X_j) \left[ \exp\{A\frac{1 - \eta}{R_w(R_j)}\} \right]^{\frac{(1 - \eta)(1 + \gamma)}{\eta(1 - \alpha)\gamma}}
\]

where \( R_w \) monotonically increases in \( R_j \)

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$$\frac{N_j}{(1 - \theta)} \geq M_n \bar{\lambda}(X_j) \left[ \exp\{A\} \frac{\eta}{1 - \eta} / R_w(R_j) \right]^{\frac{(1 - \eta)(1 + \gamma)}{\eta(1 - \alpha)\gamma}}$$

where $R_w$ monotonically increases in $R_j$

- A reduction in $N_j$ (weakly) raises firms’ borrowing costs
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\]

where \( R_w \) monotonically increases in \( R_j \)

- A reduction in \( N_j \) (weakly) raises firms’ borrowing costs

**Lemma 2.** Given \( R_j \) and \( X_j \), \( \{Y_j, w_j\} \) solve

\[
w_j = M_w \left[ \frac{\exp\{A\}^{\frac{\eta}{1-\eta}}}{R_w(R_j)} \right]^{\frac{(1-\eta)}{\eta(1-\alpha)}} \\
y_j = M_y \left[ \frac{\exp\{A\}^{\frac{\eta}{1-\eta}} / R_w(R_j)}{\exp\{A\}^{\frac{\eta}{1-\eta}} / R_y(R_j)} \right]^{\frac{1-\eta+(1-\alpha\eta)\gamma}{\eta(1-\alpha)\gamma}}
\]
Firms’ log sales are

\[ \hat{p}y(z, \lambda, X_j) = c + \frac{\eta}{1 - \eta}(A + z) - \frac{\eta}{1 - \eta} \lambda_i R(X_j) + \hat{Y}(X_j) - \frac{\eta(1 - \alpha)}{1 - \eta} \hat{w}(X_j) \]
Propagation of Sovereign Risk

Firms’ log sales are

\[ \hat{py}(z, \lambda, X_j) = c + \frac{\eta}{1 - \eta} (A + z) - \frac{\eta}{1 - \eta} \lambda_i R(X_j) + \hat{Y}(X_j) - \frac{\eta(1 - \alpha)}{1 - \eta} \hat{w}(X_j) \]

Thus, we have

\[ \frac{\partial \hat{py}(z, \lambda, X_j)}{\partial \text{spr}} = -\frac{\eta}{1 - \eta} \lambda \left( \frac{\partial R(X_j)}{\partial N_j} \frac{\partial N_j}{\partial \text{spr}} \right) + \left( \frac{\partial \hat{Y}(X_j)}{\partial N_j} - \frac{\eta(1 - \alpha)}{1 - \eta} \frac{\partial \hat{w}(X_j)}{\partial N_j} \right) \frac{\partial N_j}{\partial \text{spr}} \]

Direct effect

Indirect effects
Firms’ log sales are
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\]

- **Direct effect**: change in borrowing rates \( R(X_j) \)
  - Larger effect for high \( \lambda \) firms/high \( \varphi \) regions

- **Indirect effects**: change in demand \( Y_{jt} \) and wages \( w_{jt} \)
  - Effects homogeneous across firms, different across regions
**Propagation of Sovereign Risk**

Firms’ log sales are

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  - Effects homogeneous across firms, different across regions
Measuring Direct and Indirect Effects

**Proposition.** Up to a first order, the log-sales of firm $i$ equal

\[
\hat{y}_{i,j,k,t} = \alpha_i + \beta_1(spr_t \times \varphi_j) + \beta_2(spr_t \times \varphi_j \times \lambda_i) + \beta_3A_t + \beta_4(A_t \times \lambda_i) \\
+ \beta_5(B_t \times \varphi_j) + \beta_6(B_t \times \varphi_j \times \lambda_i) + \frac{\eta}{1-\eta}z_{k,t},
\]

- $\beta_1 \varphi_j$ are the indirect effects in region $j$
- $\beta_2 \lambda_i \varphi_j$ is the direct effect for a firm with working capital need $\lambda_i$ in region $j$
Measuring Direct and Indirect Effects

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$$
\hat{y}_{i,j,k,t} = \alpha_i + \beta_1(spr_t \times \varphi_j) + \beta_2(spr_t \times \varphi_j \times \lambda) + \beta_3A_t + \beta_4(A_t \times \lambda) \\
+ \beta_5(B_t \times \varphi_j) + \beta_6(B_t \times \varphi_j \times \lambda) + \frac{\eta}{1 - \eta} z_{k,t},
$$

- $\beta_1 \varphi_j$ are the indirect effects in region $j$
- $\beta_2 \lambda \varphi_j$ is the direct effect for a firm with working capital need $\lambda$ in region $j$

Insight: Direct and indirect effects can be identified from this regression, given proxies for $\lambda$ and $\varphi_j$ and aggregate data

- It works b/c the distribution of $z_{k,t}$ does not depend on $\lambda$ and $\varphi_j$
Difference-in-differences interpretation

Consider two periods with $\Delta spr_t > 0$, two regions $\{\varphi_L, \varphi_H\}$ and two leverage types $\{\lambda_L, \lambda_H\}$ with $\lambda_L = 0$.
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- $\beta_1$ identified by comparing relative sales growth for “zero-leverage” firms across regions
  \[
  \mathbb{E}_t [\Delta (\hat{p}y_{\lambda_L, \varphi_H, k, t} - \hat{p}y_{\lambda_L, \varphi_L, k, t})] = \beta_1 [\varphi_H - \varphi_L] \Delta \text{spr}_t,
  \]

- “Zero-leverage” not impacted by changes in borrowing rate
Difference-in-differences interpretation

Consider two periods with $\Delta \text{spr}_t > 0$, two regions $\{\phi_L, \phi_H\}$ and two leverage types $\{\lambda_L, \lambda_H\}$ with $\lambda_L = 0$

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$$E_t \left[ \Delta \left( \hat{p}y_{\lambda_L,\phi_H,k,t} - \hat{p}y_{\lambda_L,\phi_L,k,t} \right) \right] = \beta_1 [\phi_H - \phi_L] \Delta \text{spr}_t,$$

- “Zero-leverage” not impacted by changes in borrowing rate

- $\beta_2$ identified by comparing relative sales growth between high-low $\lambda$ firms, differenced out across regions

$$E_t \left[ \Delta \left( \hat{p}y_{\lambda_H,\phi_H,k,t} - \hat{p}y_{\lambda_L,\phi_H,k,t} \right) \right] - E_t \left[ \Delta \left( \hat{p}y_{\lambda_H,\phi_L,k,t} - \hat{p}y_{\lambda_L,\phi_L,k,t} \right) \right] = \beta_2 [\phi_H - \phi_L] \lambda_H \Delta \text{spr}_t.$$
Identification issues and measurement strategy

What if orthogonality condition violated? Suppose we add error term

$$\varepsilon_{i,j,t} = \gamma_{i} \xi_{t} + \eta_{j} \xi_{t} + \zeta_{i,j} \xi_{t},$$

with $\xi_{t}$ potentially correlated with $spr_{t}$
Identification issues and measurement strategy

What if orthogonality condition violated? Suppose we add error term

$$\varepsilon_{i,j,t} = \gamma_i \xi_t + \eta_j \xi_t + \zeta_{i,j} \xi_t,$$

with $\xi_t$ potentially correlated with $s_{pr_t}$

- Indirect effects not identified if $\eta_{\varphi_H} \neq \eta_{\varphi_L}$ or $\zeta_{\lambda_L,\varphi_H} \neq \zeta_{\lambda_L,\varphi_L}$
- Direct effect identified as long as differential effects between high and low $\lambda$ firms similar across regions

$$\zeta_{\lambda_H,\varphi_H} - \zeta_{\lambda_L,\varphi_H} = \zeta_{\lambda_H,\varphi_L} - \zeta_{\lambda_L,\varphi_L}$$
Identification issues and measurement strategy

What if orthogonality condition violated? Suppose we add error term

$$
\varepsilon_{i,j,t} = \gamma_i \xi_t + \eta_j \xi_t + \zeta_{i,j} \xi_t,
$$

with $\xi_t$ potentially correlated with $\text{spr}_t$

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- Direct effect identified as long as differential effects between high and low $\lambda$ firms similar across regions

$$
\zeta_{\lambda_H,\varphi_H} - \zeta_{\lambda_L,\varphi_H} = \zeta_{\lambda_H,\varphi_L} - \zeta_{\lambda_L,\varphi_L}
$$

Our measurement strategy: focus on direct effect

- Use micro data to estimate direct effect

- Infer indirect effects using structural model (Chodorow-Reich, 2014)
Outline

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Empirical Analysis

• Merge Amadeus with Bankscope at the geographic level
  • Balance-sheet observations on Italian firms
  • Balance-sheet observations on Italian banks
  • BoI data on # of bank branches by geographic unit (“Regioni”)

• Balanced panel of 300k+ firms per year

• Partition firms in four groups, depending on
  • Debt-to-asset ratio high/low leverage ($\text{lev}_i \in \{0, 1\}$)
  • Location: headquartered in regions with high/low banks’ exposure to sovereign debt ($\text{exp}_i \in \{0, 1\}$)

• Partition done using 2007 data. Firm-level regressions estimated over 2008-2015 period
The median firm is small

- 7 employees, operating revenues of 5m euros, leverage ratio of 37%
Banks’ exposure to sovereign debt in 2007

- Exposure: Gov’t debt to equity in 2007

- Construct a regional indicator by weighting banks’ debt holdings and equity by their # branches in the region

- Regions in different exposure groups have similar characteristics
Pre-trend analysis

\[ \hat{y}_{i,t} = \alpha_i + \tau_{1,t} + \tau_{2,t} \exp_i + \tau_{3,t} \text{lev}_i + \beta_t (\text{lev}_i \times \exp_i) + \delta' \Gamma_{i,t} + \varepsilon_{i,t} \]
Empirical specification

- The estimate the following relation

\[ \hat{py}_{i,t} = \alpha_i + \hat{\beta} (spr_t \times lev_i \times exp_i) + \delta' \Gamma_{i,t} + \varepsilon_{i,t} \]

where \( \Gamma_{i,t} \) include

- Region \( \times \) time fixed effects that vary by firms’ characteristic bins (industry, size, profitability, volatility)
- \( spr_t \times lev_i, TFP_t \times lev_i, TFP_t \times lev_i \times exp_i \)
- Group-specific linear time trend

- \( \hat{\beta} \): Differential sensitivity of sales to sovereign spreads between high/low leverage firms differenced across regions \( \rightarrow \) Direct effect

- The indirect effects absorbed by region \( \times \) time fixed effects
## Results

<table>
<thead>
<tr>
<th></th>
<th>Model implied</th>
<th>Baseline</th>
</tr>
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<tbody>
<tr>
<td>$\hat{\beta}$</td>
<td>-0.771</td>
<td>-0.723</td>
</tr>
<tr>
<td></td>
<td>(0.077)</td>
<td>(0.043)</td>
</tr>
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<table>
<thead>
<tr>
<th>Term</th>
<th>Yes/No</th>
<th>Yes/No</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{TFP}_t \times \text{lev}_i$</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>$\text{spr}_t \times \text{lev}_i$</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>$\text{TFP}_t \times \text{lev}_i \times \text{exp}_i$</td>
<td>yes</td>
<td>yes</td>
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<td>Group-specific linear time trends</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Firms FE</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Time $\times$ region FE</td>
<td>yes</td>
<td>no</td>
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<tr>
<td>Time $\times$ region $\times$ industry $\times$ firms’ bin FE</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.87</td>
<td>0.88</td>
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<tr>
<td>Obs.</td>
<td>2,589,772</td>
<td>2,578,355</td>
</tr>
</tbody>
</table>

Standard errors clustered at region/year level

▶ Sensitivity
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Model Parametrization

- Two regions/two leverage groups

- Process for $A_t$ estimated using TFP data

- Set some parameters to conventional values
  $$\alpha = .30, \beta = .98, \delta = .10, \varphi = .15, \eta = .75, \sigma = 2, \tau = .20, \vartheta = .05$$

- Set Frisch elasticity $(1/\gamma)$ to 0.75

- Moment matching
  - Parameters: $\{\bar{n}_j/(1 - \theta), \varphi_j/(1 - \theta), \lambda_{\text{low}}, \lambda_{\text{high}}, \sigma_z, \sigma_\nu, \rho_\nu, \bar{\nu}, \beta_g\}$
  - Moments: Distribution of firms’ leverage and banks’ exposure, $\hat{\beta}$, $\text{Stdev}(\hat{p}_i\hat{y}_{i,t})$, Moments of sovereign spreads distribution
### Calibration Targets and Out of Sample Fit

<table>
<thead>
<tr>
<th></th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Targeted moments</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stddev((\hat{p}y_{it}))</td>
<td>0.52</td>
<td>0.55</td>
</tr>
<tr>
<td>Firms’ leverage</td>
<td>[.0 .51]</td>
<td>[.0 .51]</td>
</tr>
<tr>
<td>Banks’ exposure</td>
<td>[.45 .62]</td>
<td>[.45 .62]</td>
</tr>
<tr>
<td>(\hat{\beta})</td>
<td>(-0.72)</td>
<td>(-0.77)</td>
</tr>
<tr>
<td>Mean(spr(_{t}))</td>
<td>1.0</td>
<td>1.1</td>
</tr>
<tr>
<td>Stddev(spr(_{t}))</td>
<td>1.2</td>
<td>1.1</td>
</tr>
<tr>
<td>Acorr(spr(_{t}))</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Skewness(spr(_{t}))</td>
<td>1.2</td>
<td>1.0</td>
</tr>
<tr>
<td>Corr(spr(<em>{t}),(\hat{Y}</em>{t}))</td>
<td>(-0.36)</td>
<td>(-0.60)</td>
</tr>
<tr>
<td><strong>Out of sample moments</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean(firm spr(_{t}))</td>
<td>0.33</td>
<td>0.41</td>
</tr>
<tr>
<td>Stddev(firm spr(_{t}))</td>
<td>0.77</td>
<td>0.77</td>
</tr>
<tr>
<td>Acorr(firm spr(_{t}))</td>
<td>0.53</td>
<td>0.37</td>
</tr>
<tr>
<td>Skewness(firm spr(_{t}))</td>
<td>0.73</td>
<td>2.21</td>
</tr>
<tr>
<td>Corr(spr(<em>{t}),firm spr(</em>{t}))</td>
<td>0.89</td>
<td>0.90</td>
</tr>
<tr>
<td>Corr((\hat{Y}<em>{L,t}), (\hat{Y}</em>{H,t}))</td>
<td>0.98</td>
<td>0.99</td>
</tr>
<tr>
<td>Mean(<em>{\text{crisis}})((\hat{Y}</em>{H,t} - \hat{Y}_{L,t}))</td>
<td>(-0.56)</td>
<td>(-0.56)</td>
</tr>
</tbody>
</table>
Event Analysis

- Choose \( \{A_t, \nu_t\} \) to match output and sovereign spreads in the event

- Counterfactual to measure macroeconomic spillovers of debt crisis
  - What would have happened without increase in sovereign risk?

- Counterfactual path: hold \( \nu_t \) at its 2007 level
Event

- Counterfactual paths: no change in sovereign and private sector interest rates and higher output
- “Pass-through” of $\approx 0.6$ (2.2/3.9)
## Output losses from sovereign risk

<table>
<thead>
<tr>
<th></th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>Average (11-13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output, baseline</td>
<td>-3.3</td>
<td>-6.3</td>
<td>-8.0</td>
<td>-5.9</td>
</tr>
<tr>
<td>Output, no debt crisis</td>
<td>-2.5</td>
<td>-3.2</td>
<td>-6.9</td>
<td>-4.2</td>
</tr>
<tr>
<td>Total</td>
<td>-0.8</td>
<td>-3.1</td>
<td>-1.1</td>
<td>-1.7</td>
</tr>
<tr>
<td>Direct effect</td>
<td>-1.6</td>
<td>-6.1</td>
<td>-2.1</td>
<td>-3.2</td>
</tr>
<tr>
<td>Indirect effect</td>
<td>0.8</td>
<td>3.0</td>
<td>1.0</td>
<td>1.5</td>
</tr>
</tbody>
</table>

- Average output losses of 1.7% ($\approx 1/3$ of total)
- Overall effects mostly due to direct effect
- In the paper: sensitivity to indirect effects/model with firm default
Conclusions

• Sovereign debt model with heterogeneous firms and banks

• Firm-level data useful to identify macroeconomic spillovers of Gov’t debt crisis

• Similar methodology can be used to measure other output costs of sovereign risk
Additional Material
Firms’ characteristics by leverage/exposure group

<table>
<thead>
<tr>
<th>Leverage</th>
<th>Exposure</th>
<th>Interaction</th>
<th>Leverage</th>
<th>Exposure</th>
<th>Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total assets</td>
<td>Debt</td>
<td>Leverage</td>
<td>Profitability</td>
<td>Productivity</td>
<td>Volatility</td>
</tr>
<tr>
<td>-0.5</td>
<td>0</td>
<td>0.5</td>
<td>1</td>
<td>1.5</td>
<td>-0.5</td>
</tr>
</tbody>
</table>

Graphs showing the distribution of firms' characteristics across different leverage/exposure groups.
Regional characteristics by exposure group

(mean) exposure

Dtfp (09-07)  Dtfp (12-10)  Manufacturing share  GDP per capita
GDP  Unemployment  Firms' interest rates

Return
Aggregate Time Series

Two recessions:

- 2008-2009 financial crisis not associated to sovereign risk
- 2011-2013 associated to increase in sovereign risk
## Sensitivity analysis

<table>
<thead>
<tr>
<th></th>
<th>Region controls</th>
<th>No long-term debt</th>
<th>Continuous variables</th>
<th>Unbalanced panel</th>
<th>2008-2011 subsample</th>
<th>RJ index</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\hat{\beta}$</td>
<td>-0.886</td>
<td>-0.507</td>
<td>-2.271</td>
<td>-0.464</td>
<td>-0.493</td>
<td>-1.947</td>
</tr>
<tr>
<td></td>
<td>(0.049)</td>
<td>(0.024)</td>
<td>(1.162)</td>
<td>(0.133)</td>
<td>(0.007)</td>
<td>(0.550)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.88</td>
<td>0.88</td>
<td>0.88</td>
<td>0.87</td>
<td>0.92</td>
<td>0.93</td>
</tr>
<tr>
<td>Obs.</td>
<td>2,578,355</td>
<td>2,578,355</td>
<td>2,578,355</td>
<td>3,002,873</td>
<td>1285990</td>
<td>440,850</td>
</tr>
</tbody>
</table>