Sovereign Default Risk and Firm Heterogeneity

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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 → Risk of default reflects deterioration of economic fundamentals (Arellano, 2008; Aguiar and Gopinath, 2006)
  2. Banks hold Gov't debt → 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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- 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 $\approx 1/3$ of output decline
  - Mostly due to direct effect

Model

- Central Government finances expenditure in public goods
  - Taxes firms (τ) and borrow long-term from banks (ϑ)
  - 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 (ν)

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 λ_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 ($B_{jt+1}, \{b^f_{ijt}\}$)

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

- Balance sheet and financial constraint

$$\begin{aligned} q_t B_{jt+1} + \int b^f_{ijt} di &\leq N_{jt} + q^a_{jt} A_{jt} \\ q^a_{jt} A_{jt} &\leq \theta \int b^f_{ijt} di + q_t B_{jt+1} \end{aligned}$$

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- Euler equations

$$R_{jt} = \frac{1 + \zeta_{jt}}{\beta}$$

$$q_t = \mathbb{E}_t \left\{ \beta \left[(1 - D_{t+1}) \left(\vartheta + q_{t+1}(1-\vartheta) \right) \right] \right\}$$

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

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Given $Y^a(s, D, B')$, Gov't policies solve recursive problem

- Default decision

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

- The value of repaying solves

$$V(s) = \max_{B'} u_g(G) + \beta_g \mathbb{E}\, W(s')$$

$$G + \vartheta B = \tau Y^a(s, D, B') + q(s, B')\left[B' - (1-\vartheta)B\right]$$

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

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

where R_w monotonically increases in R_j

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Lemma 2. Given R_j and X_j, $\{Y_j, w_j\}$ solve

$$w_j = M_w \left[\frac{\exp\{A\}^{\frac{\eta}{1-\eta}}}{R_w(R_j)}\right]^{\frac{(1-\eta)}{\eta(1-\alpha)}} \qquad Y_j = M_y \frac{\left[\exp\{A\}^{\frac{\eta}{1-\eta}} / R_w(R_j)\right]^{\frac{1-\eta+(1-\alpha\eta)\gamma}{\eta(1-\alpha)\gamma}}}{\exp\{A\}^{\frac{\eta}{1-\eta}} / R_y(R_j)}$$

Propagation of Sovereign Risk

Firms' log sales are

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

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- Direct effect: change in borrowing rates $R(X_j)$
  - Larger effect for high λ firms/high φ regions
- Indirect effects: change in demand Y_{jt} and wages w_{jt}
  - 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

$$\begin{aligned} \hat{py}_{\iota,j,k,t} &= \alpha_i + \beta_1(\mathrm{spr}_t \times \varphi_j) + \beta_2(\mathrm{spr}_t \times \varphi_j \times \lambda_\iota) + \beta_3 A_t + \beta_4(A_t \times \lambda_\iota) \\ &+ \beta_5(B_t \times \varphi_j) + \beta_6(B_t \times \varphi_j \times \lambda_\iota) + \frac{\eta}{1-\eta} z_{k,t}, \end{aligned}$$

- $\beta_1 \varphi_j$ are the indirect effects in region j
- $\beta_2 \lambda_\iota \varphi_j$ is the direct effect for a firm with working capital need λ_ι in region j
- Our strategy: use micro data to estimate direct effect, infer indirect effects using structural model (Chodorow-Reich, 2014)

DiD interpretation

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

Firms' summary statistics in 2007

	Obs.	Mean	P25	P50	P75
Number of employees	123,514	27	3	7	18
Operating revenues	336,047	40543	1118	5083	17972
Total assets	336,047	44273	2635	7465	21239
Debt	336,047	8680	0	342	3623
Accounts receivable	336,047	7842	35	657	3518
Leverage	336,047	0.38	0.07	0.37	0.63

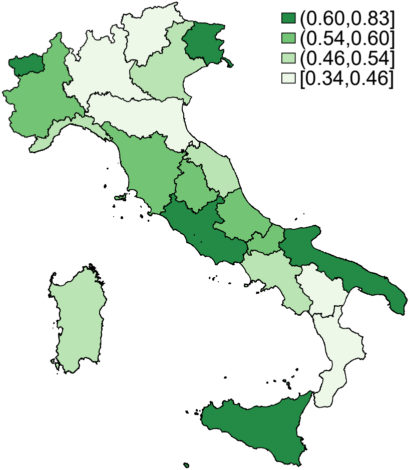
The median firm is small

- 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

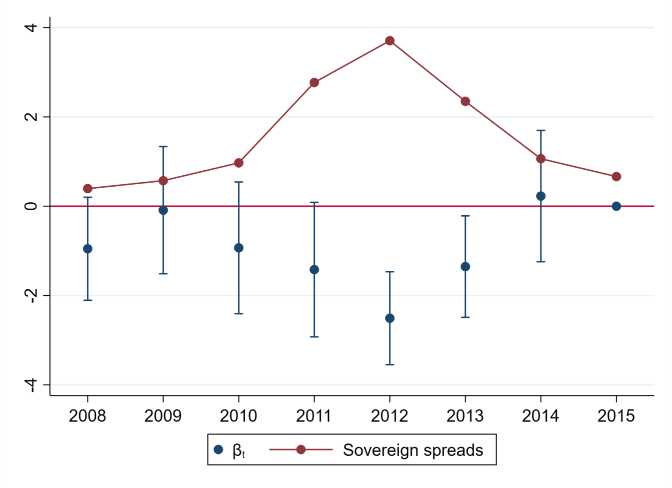
▸ Aggregate ▸ Distribution of firms



▸ Aggregate time series

Pre-trend analysis

$$\hat{py}_{i,t} = \alpha_i + \tau_{1,t} + \tau_{2,t}\ \exp_i + \tau_{3,t}\ \mathrm{lev}_i + \beta_t\ (\mathrm{lev}_i \times \exp_i) + \delta'\Gamma_{i,t} + \varepsilon_{i,t}$$



Empirical specification

- The estimate the following relation

$$\hat{py}_{i,t} = \alpha_i + \hat{\beta}\,(\text{spr}_t \times \text{lev}_i \times \text{exp}_i) + \delta' \Gamma_{i,t} + \varepsilon_{i,t}$$

  where $\Gamma_{i,t}$ include

  - Region $\times$ time fixed effects that vary by firms' characteristic bins (industry, size, profitability, volatility)
  - $\text{spr}_t \times \text{lev}_i$, $\text{TFP}_t \times \text{lev}_i$, $\text{TFP}_t \times \text{lev}_i \times \text{exp}_i$
  - 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

	Model implied	Baseline
$\hat{\beta}$	-0.771	-0.723
	(0.077)	(0.043)
$\text{TFP}_t \times \text{lev}_i$	yes	yes
$\text{spr}_t \times \text{lev}_i$	yes	yes
$\text{TFP}_t \times \text{lev}_i \times \text{exp}_i$	yes	yes
Group-specific linear time trends	yes	yes
Firms FE	yes	yes
Time × region FE	yes	no
Time × region × industry × firms' bin FE	no	yes
R^2	0.87	0.88
Obs.	2,589,772	2,578,355

Standard errors clustered at region/year level

▸ Sensitivity

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, $\hat{\beta}$, Stdev$(\hat{py}_{i,t})$, Moments of sovereign spreads distribution

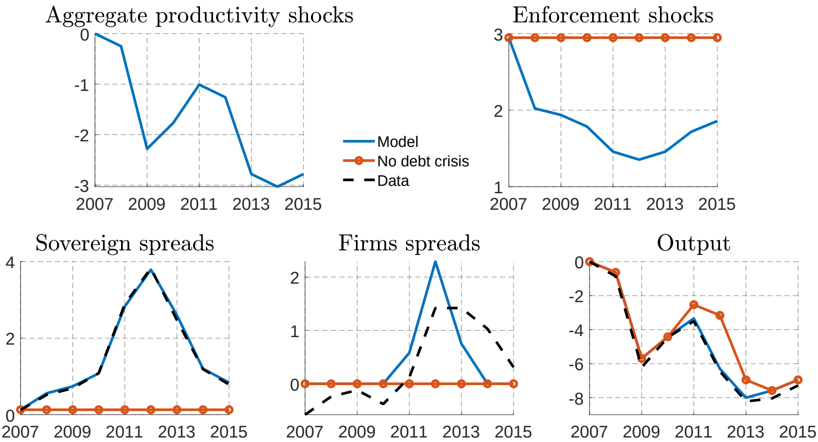
Calibration Targets and Out of Sample Fit

	Data	Model
Targeted moments		
Stdev($\hat{py}_{it}$)	0.52	0.55
Firms' leverage	[.0 .51]	[.0 .51]
Banks' exposure	[.45 .62]	[.45 .62]
$\hat{\beta}$	-0.72	-0.77
Mean(spr_t)	1.0	1.1
Stdev(spr_t)	1.2	1.1
Acorr(spr_t)	0.8	0.8
Skewness(spr_t)	1.2	1.0
Corr($\text{spr}_t, \hat{Y}_t$)	-0.36	-0.60
Out of sample moments		
Mean(firm spr_t)	0.33	0.41
Stdev(firm spr_t)	0.77	0.77
Acorr(firm spr_t)	0.53	0.37
Skewness(firm spr_t)	0.73	2.21
Corr(spr_t, firm spr_t)	0.89	0.90
Corr($\hat{Y}_{L,t}$, $\hat{Y}_{H,t}$)	0.98	0.99
$\text{Mean}_{\text{crisis}}(\hat{Y}_{H,t} - \hat{Y}_{L,t})$	-0.56	-0.56

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 ν_t at its 2007 level

Event



- Counterfactual paths: no change in sovereign and private sector interest rates and higher output
- "Pass-through" of ≈ 0.6 $(2.2/3.9)$

Output losses from sovereign risk

	2011	2012	2013	Average (11-13)
Output, baseline	-3.3	-6.3	-8.0	-5.9
Output, no debt crisis	-2.5	-3.2	-6.9	-4.2
Output losses from sovereign risk				
Total	-0.8	-3.1	-1.1	-1.7
Direct effect	-1.6	-6.1	-2.1	-3.2
Indirect effect	0.8	3.0	1.0	1.5

- 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 heterogenous 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

Difference-in-differences interpretation

Consider two periods with $\Delta\mathrm{spr}_t > 0$, two regions $\{\varphi_L, \varphi_H\}$ and two leverage types $\{\lambda_L, \lambda_H\}$ with $\lambda_L = 0$

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- β_1 identified by comparing relative sales growth for "zero-leverage" firms across regions

$$\mathbb{E}_t\left[\Delta\left(\hat{py}_{\lambda_L,\varphi_H,k,t} - \hat{py}_{\lambda_L,\varphi_L,k,t}\right)\right] = \beta_1[\varphi_H - \varphi_L]\Delta spr_t,$$

  - "Zero-leverage" not impacted by changes in borrowing rate

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  - "Zero-leverage" not impacted by changes in borrowing rate

- β_2 identified by comparing relative sales growth between high-low λ firms, differenced out across regions

$$\begin{aligned}\mathbb{E}_t\left[\Delta\left(\hat{py}_{\lambda_H,\varphi_H,k,t} - \hat{py}_{\lambda_L,\varphi_H,k,t}\right)\right] &- \mathbb{E}_t\left[\Delta\left(\hat{py}_{\lambda_H,\varphi_L,k,t} - \hat{py}_{\lambda_L,\varphi_L,k,t}\right)\right] \\ &= \beta_2[\varphi_H - \varphi_L]\lambda_H\Delta spr_t.\end{aligned}$$

Identification issues and measurement strategy

What if orthogonality condition violated? Suppose we add error term

$$\varepsilon_{\iota,j,t} = \gamma_\iota \xi_t + \eta_j \xi_t + \zeta_{\iota,j} \xi_t,$$

with ξ_t potentially correlated with spr_t

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- 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 λ firms similar across regions

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

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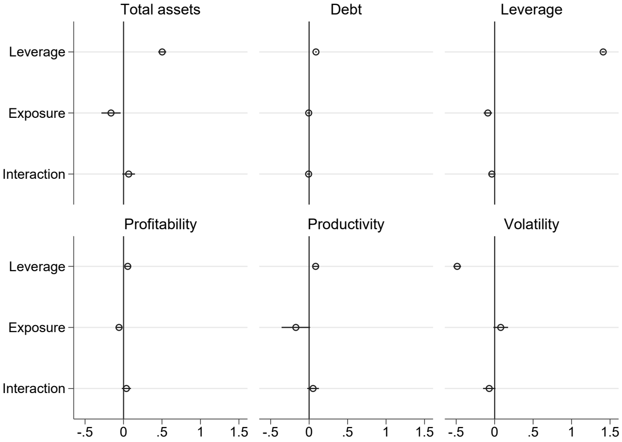
Our measurement strategy: focus on direct effect

- Use micro data to estimate direct effect
- Infer indirect effects using structural model (Chodorow-Reich, 2014)

Return

Firms' characteristics by leverage/exposure group



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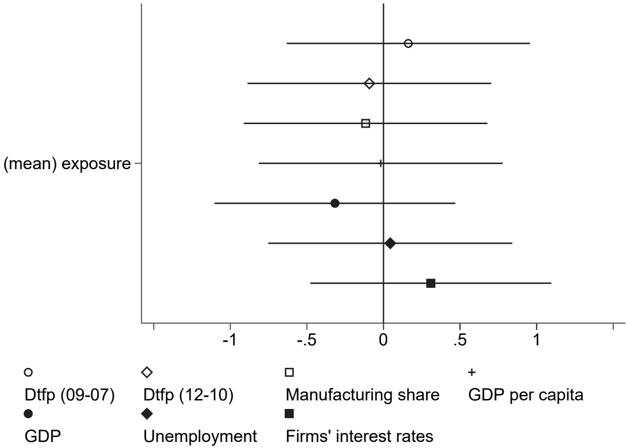
Regional characteristics by exposure group



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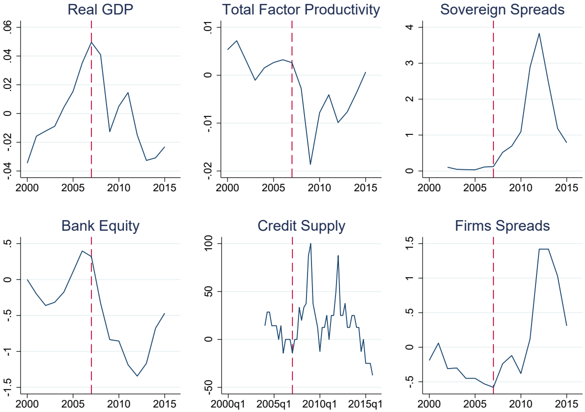
Aggregate Time Series



Two recessions:

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

Return

Sensitivity analysis

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

Return