Sovereign Default Risk and Firm Heterogeneity

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Motivation

- Debt crisis in Southern European countries

  - Govt spreads rose substantially

  - Decline in economic activity, since 2007 GDP fell 10-20 %

Motivation

- ▶ Debt crisis in Southern European countries

  - ▶ Govt spreads rose substantially
  - ▶ Decline in economic activity, since 2007 GDP fell 10-20 %

- ▶ What is the effect of govt crisis on private economy?

  - ▶ Govt crisis harms private economy
    Neumeyer-Perri (2005), Uribe-Yue (2005), Bocola (2015), Corsetti et al (2013)

  - ▶ Govt crisis reflects bad private conditions (Govt is a veil)
    Aguiar-Gopinath (2006), Arellano (2008), Mendoza-Yue (2012)

- ▶ Challenge to answer using aggregate data

  - ▶ Both imply negative comovement of output and govt spreads

Our Approach

- ► Develop model of govt default with heterogeneous firms

    - ► Private economy affects govt through tax revenues
    - ► Govt spreads affect economy through firms' borrowing rates
    - ► Two aggregate shocks: productivity and enforcement

- ► Model has both time series *and* cross sectional predictions

- ► Use govt spread series cross sectional moments to

    - ► Measure *pass-through* of govt risk on private sector
    - ► Quantify effects on output and firms spreads
    - ► Identify whether shocks originated in private or public sector

Key Idea

- Cross sectional moments inform govt pass-through

    - Govt crisis affects real economy by raising private borrowing rates
    - Firms with greater financing needs expected to be more affected

- Amadeus micro data to measure firms performance during govt crisis

    - Firms sales decline during the govt debt crisis
    - Effect stronger for highly levered firms

- Discipline govt pass-through with differential response of firms

Results

- Model calibrated to micro and aggregate data in Italy

  - Pass-through to differential response of firms to govt spread
  - Enforcement shock to govt spreads
  - Productivity shock to firm productivity

- Use calibrated model to interpret the recent crisis

- Model accounts for observed decline in output

  - Pass-through of govt crisis accounts for about 50% of decline
  - Productivity shock accounts for about 50% of decline

- Pass-through of govt crisis disciplines govt and lowers default risk

Model

- ▶ Heterogeneous firms that borrow and default

- ▶ Government values public goods, borrows, and defaults

- ▶ Firms face idiosyncratic shocks, produce, borrow, and default

- ▶ Firms' borrowing rates depend on government spread

- ▶ Aggregate shocks: productivity and public default cost

Firms

- Face shocks to productivity z_{it} and revenues ξ_{it}

- Produce with capital k_{it} and labor ℓ_{it}

- Rent capital and hire workers before idiosyncratic shocks, constant prices

- Finance λ_i of input costs with loan b_{it} at price q_{it}

$$q_{it}b_{it} = \lambda_i(r^k k_{it} + w\ell_{it})$$

- Firms profits are

$$\pi_{it} = z_{it}(k_{it}^{\alpha}\ell_{it}^{1-\alpha})^{\eta} - (1-\lambda_i)(w\ell_{it} + r^k k_{it}) - b_{it} - \xi_{it} \geq 0$$

- Default $d_{it} = 1$ if value is negative

  Exit; replaced with identical firm; output pays for inputs

Productivity Shock

- Firm productivity has idiosyncratic and aggregate component

$$z_{it} = \rho z_{it-1} - I_{it}\mu + \sigma^z \varepsilon_{it}$$

$$\Pr(I_{it} = 1) = p_t$$

- Productivity shock: p_t probability of idiosyncratic disaster

- i.i.d. p_t has persistent effects on distribution of firms

Firms Bond Price Function

▶ Firm price compensates for default and depends on govt. spread s_t^g
(Neumeyer and Perri 2005)

$$q_{it} = E\left[\frac{(1 - d_{it})}{1 + \gamma s_t^g}\right]$$

▶ Arises in models where intermediaries have leverage constraints
(Bocola 2015)

▶ γ controls extend of passthrough

  ▶ We will discipline it using cross section data

Pass-through: Govt Spread on Firms

- Firms choose k and ℓ in proportion

- Abstracting from firm default, optimal capital k^*

$$\eta E[z|z_{-1}, p](k^*)^{\eta-1} = (1 + \lambda\gamma s^g)\tilde{r}^k$$

- Capital decreases with govt spread

$$\frac{\partial log(k^*)}{\partial s^g} = -\frac{1}{1-\eta}\gamma\lambda < 0$$

- More so for high leverage firms

$$\frac{\partial^2 log(k^*)}{\partial s^g \partial \lambda} = -\frac{1}{1-\eta}\gamma < 0$$

- Differential response sufficient statistic to measure pass-through

- Capital decreases with productivity, and not differentially with λ

Government

- Government budget constraint

$$B_t + G_t = q_{t+1}^g B_{t+1} + \tau Y_t$$

  - Finances debt B_t and expenditure G_t
  - Collects revenue τY_t

- Values public consumption and faces default costs shocks

$$E_0 \sum_{t=0}^{\infty} \beta_g^t (u_g(G_t) - \nu_t I_{D_t=1})$$

- Default $D_t = 1$ induces utility cost, reduces debt to R

Enforcement shock: ν_t default cost shock, Markov process

Government Borrowing

- ► Govt faces schedule for bond prices and tax revenue

$$G + B = q^g(\nu, p, \Lambda, B')B' + \tau Y(\nu, p, \Lambda, B')$$

- ► Bond price schedule compensates for default risk
    - ► High B' lower q^g due to default risk
    - ► Government spread $s^g = 1/q^g - (1 + r)$

- ► Tax schedule incorporates pass-through
    - ► High B' increases govt spread which also reduces revenue
    - ► Pass-through makes schedule tighter

- ► Optimal government borrowing satisfies

$$u'_g(G) \left[q^g + \frac{\partial q^g}{\partial B'} B' + \tau \frac{\partial Y}{\partial B'} \right] = \beta_g E[u'_g(G')|D' = 0]$$

- ► Pass-through also lowers incentive to borrow

Summary of the Model

▶ Government and heterogeneous firms

  ▶ Private economy affects govt through tax revenues

  ▶ Govt spreads affect firms' borrowing rates

  ▶ Two way feedback loop

  ▶ Two aggregate shocks: productivity and enforcement

▶ Key cross-section implication:

  High-leverage firms respond more to government spread

Quantitative Analysis

- Empirical prediction borne in Italian firm level data

    - Firms output decrease with low prod and high govt spread
    - Firms with high leverage affected more by govt spread

- Use cross section moments measure pass-through

- Impulse response functions to shocks

- Event analysis and counterfactuals

Data

Firm balance sheet data for Italy, Amadeus, 2005 to 2013, 175000+ obs

- ▶ Recover firm productivity z_{it} (Wooldrige (2009))

- ▶ Use distribution of z_{it} to measures aggregate shock p_t

- ▶ Use firm sales growth and leverage to measure

    Differential effects w.r.t. productivity and govt spread

Aggregate Productivity Shock
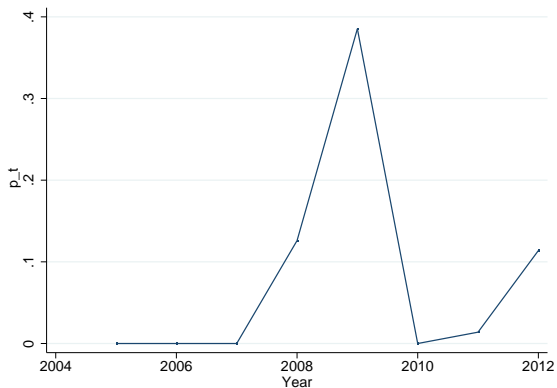
- Low productivity 2009 and 2012

Differential Effects on Sales Growth

	Benchmark	Spread Only	Productivity Only
s_t^g	-0.82^{***}	-1.45^{**}	
	(0.18)	(0.70)	
$s_t^g \times \text{lev}_{i,t}$	-1.7^{***}	-2.2^{***}	
	(0.32)	(0.78)	
p_t	-0.66^{***}		-0.67^{***}
	(0.03)		(0.03)
$p_t \times \text{lev}_{i,t}$	0.11^{***}		0.03
	(0.04)		(0.08)
$\text{lev}_{i,t}$	28^{***}	41^{***}	29^{***}
	(4.3)	(13)	(3.8)
firm fixed effects	yes	yes	yes
Adjusted R^2	16	5	15

- ▶ Growth falls by 0.8% more with a 1% increase in spr_t for firms with leverage at 75 pct (0.52) relative to 25 pct (0.2)

- ▶ Growth falls for ALL firms with increase in p_t

- ▶ Robust finding in various regression specifications

Quantitative Strategy

- Measure private shock p and z directly with firm level data

- Recover pass-through parameter and enforcement shock

  Differential effect of spread on firms based on leverage

  Government spread series

- Target other firm moments for firm parameters

Pass-through coefficient	$\gamma = 0.4$	Regression coefficient
Volatility enforcement shock	$\sigma_\nu = 0.3$	Mean govt spread
Government discount factor	$\beta = 0.88$	Volatility govt spread
Mean enforcement shock	$\bar{\nu} = 1.0$	Short public debt / Output
Debt Recovery	$R = 0.13$	Cruces and Trebesch (2013)
Volatility revenue shock	$\sigma_\xi = 0.3$	Mean firm spread
Mean revenue shock	$\bar{\xi} = 3.75$	Mean firm profit/sale
Financing requirement	$\{\lambda_1 = 0.4, \lambda_2 = 1.0\}$	Firm leverage 25 and 75 pct

Other parameters from literature: preferences, technology

Moments in Data and Model

	Data	Model
Interaction coeff$\times[\overline{\lambda}_{75,t} - \overline{\lambda}_{25,t}]$	-0.54	-0.57
Govt spread mean	1.8	1.9
Govt spread volatility	1.1	0.9
Short debt/output	25	28
Recovery	60	54
Firms spread	2.3	1.8
Firms profits	2.5	3
Firms leverage 25 and 75 pct	[20,50]	[20,50]
Other Moments		
Corr (Firm spread, Govt spread)	82	98
Corr (Output, Govt spread)	-54	-79

▶ Positive correlation between firm and govt spreads

Mechanisms: Firm Decisions
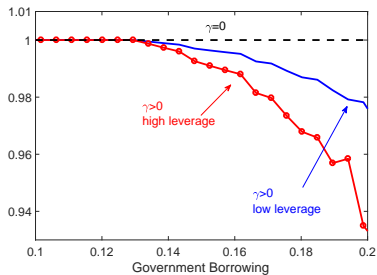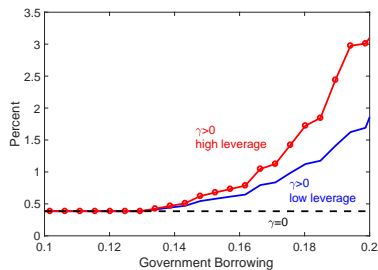
Firm Capital   Firm Spread

- ▶ High government borrowing $->$ high govt spreads
- ▶ Decrease capital with govt borrowing, more for high leverage firm
- ▶ No pass-through: govt borrowing no effect on production or firm spreads

Mechanisms: Government Tax and Spread Schedules
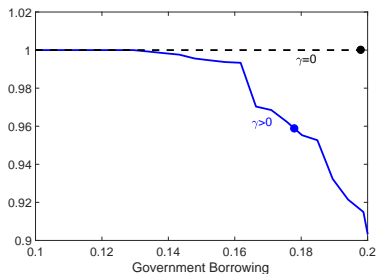

Tax Schedule
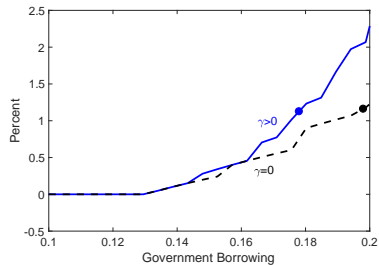
Spread Schedule

▶ High borrowing lowers tax revenue (sovereign debt overhang effects)
  No pass-through: tax revenues not affected with borrowing

▶ High government borrowing increases govt spreads
  No pass-through: spreads increase more slowly with borrowing

▶ Pass-through disciplines borrowing
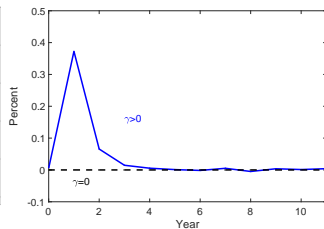
Aggregate Effects: IRF to Enforcement Shock
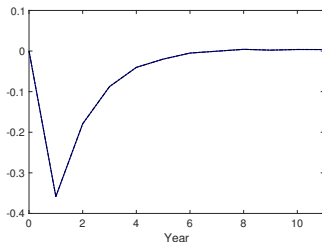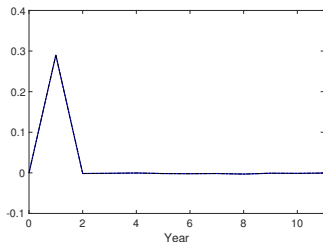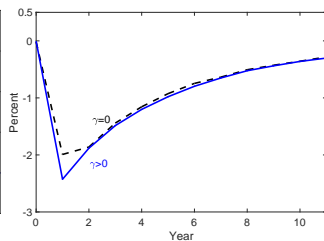

Enforcement shock
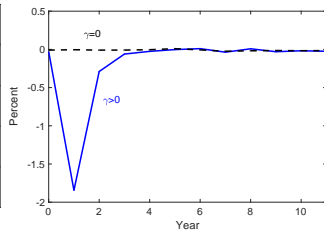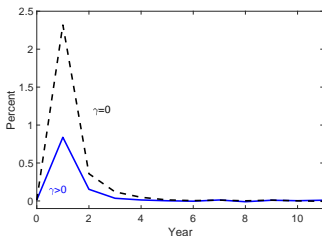
Output

Government spread

Firm spread

- ▶ Loop: low enforcement, high govt and firm spreads, low output
- ▶ No pass-through: no effects on private sector, larger effects on govt spread
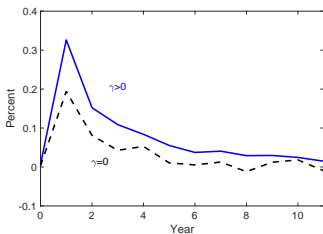
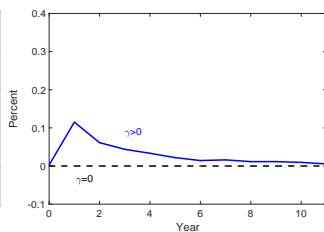# Aggregate Effects: IRF to Productivity Shock

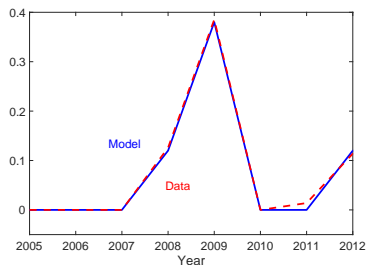

Enforcement shock

Output

Government spread

Firm spread

- ▶ Loop: low productivity, low output, increases in govt and firms spread
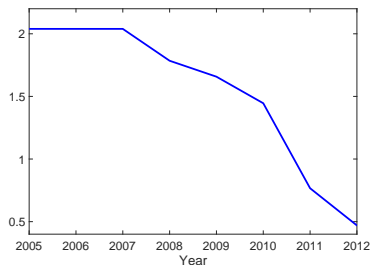- ▶ No pass-through: more muted but similar effects

Event Analysis: Model Fit

- Feed in observed p_t

- Feed ν_t to match govt spread

- Evaluate effect output, govt and firm spreads

Event: Shocks

(a) Productivity shock   (b) Enforcement shock
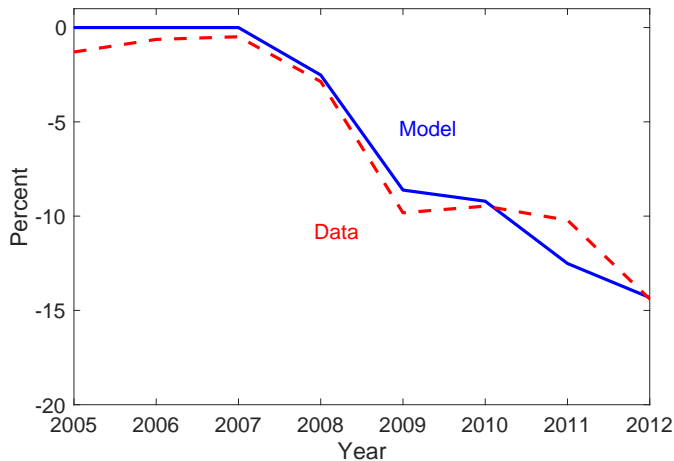
- ▶ p_t shock, big increase in 2009

- ▶ ν_t path calls for decrease in debt enforcement

Event: Govt Spread
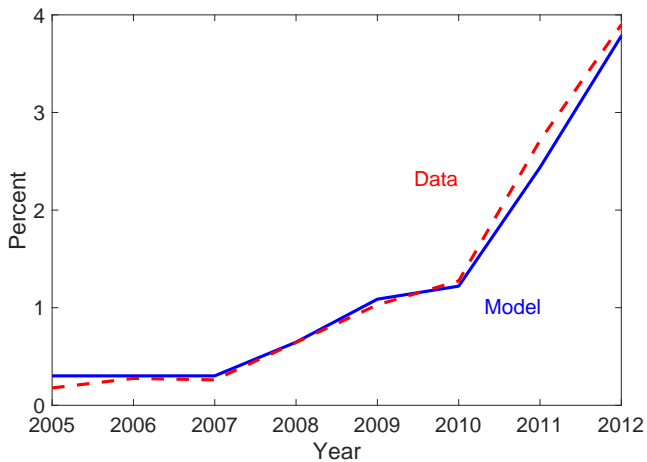
▶ Can match large increase in 2011-2012

Event: Output

- Model can account for the decline aggregate output
- Good out of sample fit

Event: Firm Spreads
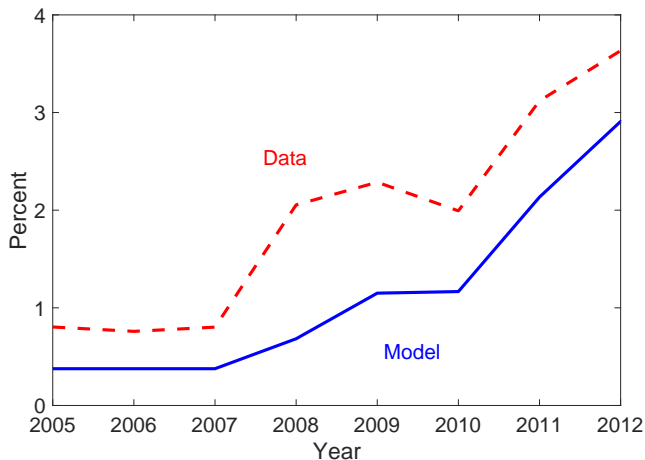
- ▶ Model predicts sizable increase in firm spreads
- ▶ Default probability for firms increases by 1.1%

Event Counterfactual: No Pass-through

If no feedback from govt to private, would there had been a crisis?

- ▶ Use model with no pass-through $\gamma = 0$

- ▶ Feed in recovered p_t and ν_t shocks

- ▶ Evaluate prediction on output, govt and firm spreads

- ▶ Difference in responses nets out sovereign risk role

Event Counterfactual: Output
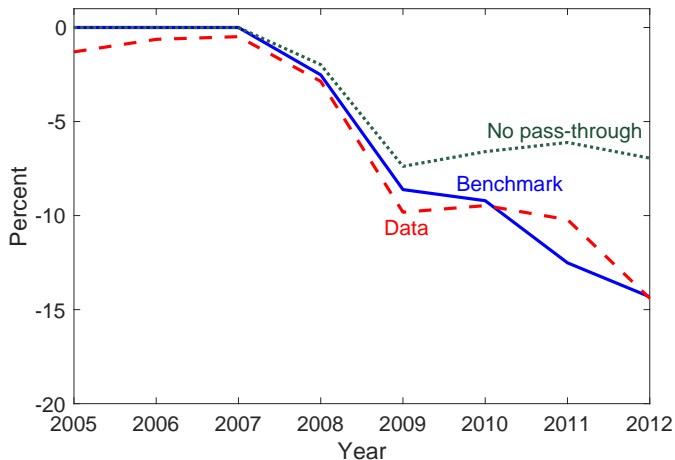
- Half of the decline in output
- Strong propagation of sovereign risk to private sector

Event Counterfactual: Govt Spreads
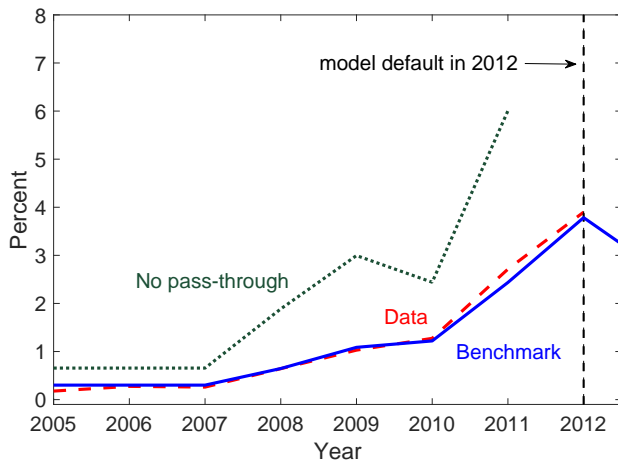
- ► Much higher spreads and default
- ► Pass-through provides discipline to government

Event Counterfactual: Firm Spreads

- ▶ Very muted firm spreads
- ▶ Unconnected to sovereign spreads

Summary Event: Italy 2007-2012

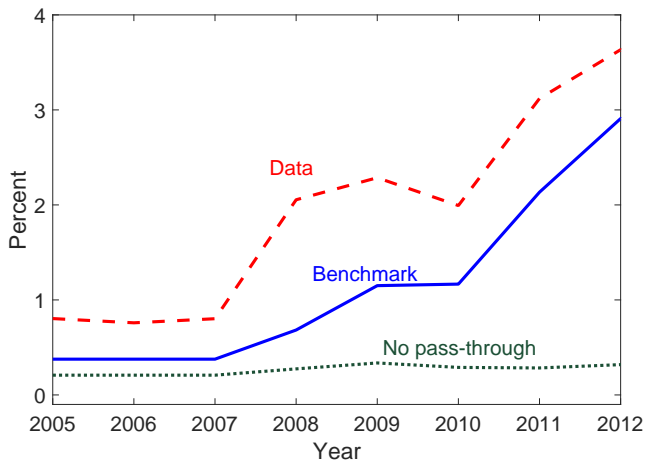|	Government spreads	Firms spreads	Output
Data	3.6	2.8	-13.9
Benchmark Model	3.5	2.5	-14.3
No pass-through	4.1	0.1	-7.0
Other counterfactuals			
Benchmark only p shocks	0.4	0.4	-7.6
Benchmark only ν shocks	1.6	1.2	-6.3
Less govt borrowing	1.5	1.7	-9.7

- ▶ Pass-through accounts: 50% of output and most of spread increase
- ▶ Productivity important for output, enforcement important for spreads and output
- ▶ Less government borrowing alleviates crisis – sovereign debt overhang

Conclusions

- ► Build model with heterogenous firms and govt default

- ► Micro data and model useful for measuring effect of govt crisis on private economy

- ► Govt effect on private economy crucial for rationalizing recession in Italy

Literature

▶ Government crises affects aggregates through financial channel

   Neumeyer-Perri (2005), Uribe-Yue (2005), Bocola (2015)

▶ Aggregate shocks drive fluctuations and sovereign crisis

   Aguiar-Gopinath (2006), Arellano (2008), Mendoza-Yue (2012)

▶ Decomposition of shocks in Euro Crisis

   Philippon-Martin (2014)

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Literature mostly uses aggregate data

- ▶ Here we use micro data to identify shocks

  Gopinath, Kalemli-Ozcan, Karababounis, Villegas-Sanchez (2015)

Firm Recursive Problem

- Let $X = \{\nu, p, \Lambda, B'\}$ be the aggregate state

- Choose capital and labor in proportion

$$v(z_{-1}, \lambda, X) = \max_{b,k} E \ \max \left\{ \pi + \frac{1}{1+r} v(z, \lambda, X'), \quad 0 \right\}$$

subject to

$$\pi = Mzk^{\eta} - (1-\lambda)\tilde{r}^k k - b - \xi \geq 0$$

- Financing requirement

$$q(b, k; z_{-1}, \lambda, X)b = \lambda \tilde{r}^k k$$

- Profits are

$$\pi = M \ zk^{\eta} - (1-\lambda)\tilde{r}^k k - b - \xi$$

- Firm bond price

$$q(b, k; z_{-1}, \lambda, X) = E \left[\frac{1 - d(b, k; z_{-1}, \lambda, X)}{1 + \beta s^g(X)} \right]$$

- Take as given evolution of aggregate state, and mapping $s^g(X)$

Government

- Exogenous states: enforcement shock ν, productivity shock p

- Endogenous states: debt B, distribution of firms $\Lambda(z_{-1}, \lambda)$

- Tax revenue function of choices

$$T(\nu, p, \Lambda, B') = \tau \sum_{z,\lambda} \Lambda(z_{-1}, \lambda) E\ y(z, z_{-1}, \lambda; \nu, p, \Lambda, B') - F(\nu, p, \Lambda, B')$$

Government Recursive Problem

- Chooses to default or not $D = \{0, 1\}$

$$W(\nu, p, B, \Lambda) = \max \ \{(1 - D) V(\nu, p, B, \Lambda) + D \ (V(\nu, p, R, \Lambda) - \nu)\}$$

- Chooses public consumption and borrowing

$$V(\nu, p, B, \Lambda) = \max_{B'} \ u_g(G) + \beta_g E \ W(\nu', p', B', \Lambda')$$

- Budget constraint
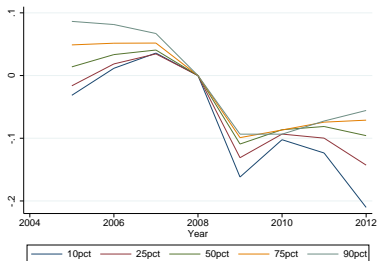
$$G + B \leq T(\nu, p, \Lambda, B') + q^g(\nu, p, \Lambda, B')B'$$
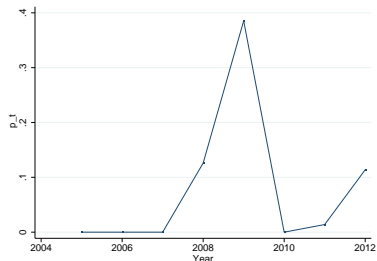
- Govt bond price

$$q^g(\nu, p, \Lambda, B') = \frac{1}{1 + r} E \ \left[1 - D(\nu', p', B', \Lambda')(1 - R/B')\right]$$

- Government spread is $s^g = 1/q^g - (1 + r)$

Aggregate Productivity Shock

Firm Productivity Pct

Productivity shock

- ▶ Low productivity 2009 and 2012
- ▶ Decline productivity more pronounced left tail

Differential Effects on Sales Growth: Robustness

	Benchmark	Broad Leverage	Mean Leverage	More Firm Controls	+ Interactions
$s_t^g \times \text{lev}_{i,t}$	-1.7^{***}			-2.2^{***}	-2.6^{***}
$p_t \times \text{lev}_{i,t}$	0.11^{***}			0.05	0.05
$s_t^g \times \text{broad lev}_{i,t}$		-2.9^{***}			
$p_t \times \text{broad lev}_{i,t}$		0.3^{**}			
$s_t^g \times \overline{\text{lev}}_i$			-1.5^{***}		
$p_t \times \overline{\text{lev}}_i$			-0.13^{***}		
$s_t^g \times \text{profitability}_{i,t}$					-5.7^{***}
$s_t^g \times \text{size}_{i,t}$					21^{***}
$s_t^g \times \text{collateral}_{i,t}$					-0.94^{***}
$s_t^g \times \text{volatility}_{i,t}$					-6.3^{***}
s_t^g	-0.82^{***}	0.53	-1.02^{***}	-0.39^{***}	5.2^{***}
p_t	-0.66^{***}	-0.82^{**}	-0.6^{***}	-0.6^{***}	-0.6^{***}
Firm controls	yes	yes	yes	yes	yes
Adjusted R^2	16	16	14	27	27

Other Moments in Data and Model

	Data	Model
Aggregate Moments		
Corr (Firm spread, Govt spread)	82	98
Corr (Output, Govt spread)	-54	-79
Firm Moments		
Sales Growth (St. Dev)	26	30
Leverage (St. Dev)	21	14
Profits/Assets (St. Dev)	8	2
Interest/Assets (St. Dev)	1	0.4
Corr (Leverage, Profits/Assets)	-18	-6
Corr (Leverage, Interest/Assets)	40	96
Corr (Profits/Assets, Sales Growth)	28	14

- Positive correlation between firm and govt spreads
- Broadly consistent with firm st dev. and correlations