Investment Slumps during Financial Crises: The Role of Credit Constraints

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Motivation

- **How much do credit constraints contribute to investment slumps during financial crises?**
- Investment is a volatile and pro-cyclical component of output, decreasing during recessions
- Financial crises are associated with even stronger declines of investment (Schularick and Taylor). **Why?**
  - banking crises
  - deleveraging

Motivation

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- Investment is a volatile and pro-cyclical component of output, decreasing during recessions
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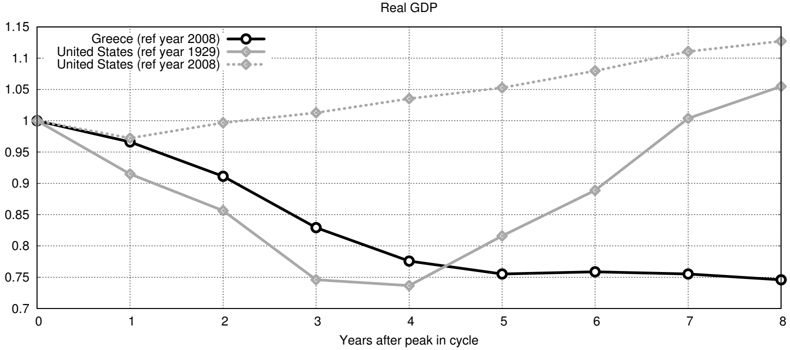
  - banking crises
  - deleveraging
- We answer this question by studying the **Greek financial crisis**
  - clear banking crisis → forces firms to **deleverage** thus affecting investment
  - detailed firm level data → granularity allowing to **control for profitability/investment opportunities** and leverage
  - investment cycle → expansion (2002-2007) and contraction period (2010-2014)

The Greek crisis



◂ Aggregate Investment

Questions and main findings

1. Can a model of investment with only profitability shocks replicate the observed fall of investment? → **No. Only about half of it**
   - heterogeneity of profitability shocks (many firms with positive sales growth) but overall decline in investment rates
2. Does adding credit constraints explain the fall of investment? → **Yes. The remaining half.**
   - deleveraging forces firms to forgo investment opportunities

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- **Details**: census-type firm level data from Greek manufacturing sector (2002-2014)
- **Methodology**:
  - estimate reduced form investment regressions
  - estimate structural dynamic model of investment

Related literature

- **Ambiguous reduced form evidence on the role of leverage during a financial crisis**: Duchin, Ozbas, Sensoy (2010), and Catherine, Chaney, Huang, Sraer, and Thesmar (2018), vs. Kahle and Stulz (2013)
  - firm investment during the US great recession

- **Dynamic models of investment and debt**: Whited (1992), Hennessy and Whited (2007), Khan and Thomas (2013)
  - financial frictions can provide an important channel of investment distortion

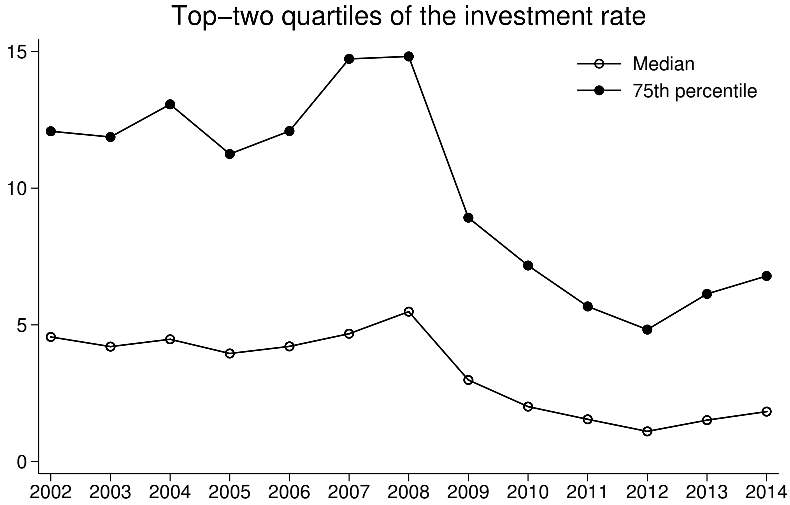
Data

- Census-type data from the Annual Survey of Manufactures (EBE), administered by the Greek Statistical Agency (ELSTAT)
- Panel of manufacturing firms with at least 10 employees over the years 2002-2014 (covers about half the manufacturing employment of manufacturing sector)
- Variables include: **firm inputs/outputs** and **balance sheet** data

Roadmap

1. We show reduced-form evidence that about 50% of the investment collapse during the Greek crisis cannot be accounted by fundamentals
2. We show that firms entering crisis with higher leverage cut investment more during the crisis period
3. We estimate a structural dynamic model of investment without debt using the pre-crisis period $\rightarrow$ cannot account for the observed investment collapse during the crisis
4. We augment the investment model to allow for debt and financial frictions and calibrate for the observed debt drop $\rightarrow$ generates the observed investment collapse

Reduced form evidence on the investment collapse



Sales growth distribution

Reduced form evidence on the investment collapse

Using investment as dependent variable, evaluate whether fundamentals can explain investment during the crisis period:

$$Investment_{it} = \beta_c Crisis_{it} + \gamma controls_{it} + \nu_{it}$$

where:

- controls → fundamentals as $K_{it}, \Delta \log sales_{it}$ and interactions
- financial crisis → dummy $Crisis = 1$ if $t \in [2010 - 2014]$

Reduced form evidence on the investment collapse

Model	$E(y\|x)$	$Med(y\|x)$	$Quant_{80}(y\|x)$	$E(y\|x)$
Dep var	I/K	I/K	I/K	$\log I$
$2010-14$ *dummy*	-0.049^{***}	-0.023^{***}	-0.069^{***}	-0.74^{***}
Controls and sector FE	yes	yes	yes	yes
N	19,748	19,748	19,748	15,899

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- The presence of the **crisis dummy has a significant** impact ($\sim$ 52%) on investment fall even after controlling for fundamentals
- This result is robust across the investment distribution including inaction (twice more likely) and spikes (half as likely; spikes account for 47% of aggregate investment)

The role of external-finance dependence

Model	$E(y\|x)$	$Med(y\|x)$	$Quant_{80}(y\|x)$	$E(y\|x)$
Dep var	I/K	I/K	I/K	$\log I$
$2010-14$ *dummy*	-0.049^{***}	-0.024^{***}	-0.069^{***}	-0.73^{***}
$2010-14$ *dummy* $\times$ *RZ*	-0.010^{***}	-0.0054^{***}	-0.012^{***}	-0.061^{***}
Controls and sector FE	yes	yes	yes	yes
N	19,748	19,748	19,748	15,899

- The Rajan and Zingales (1998) variable $RZ = Med\left\{\frac{Inv - varProfit}{Inv}\right\}$ measures a sector dependence on external finance computed during the pre-crisis period

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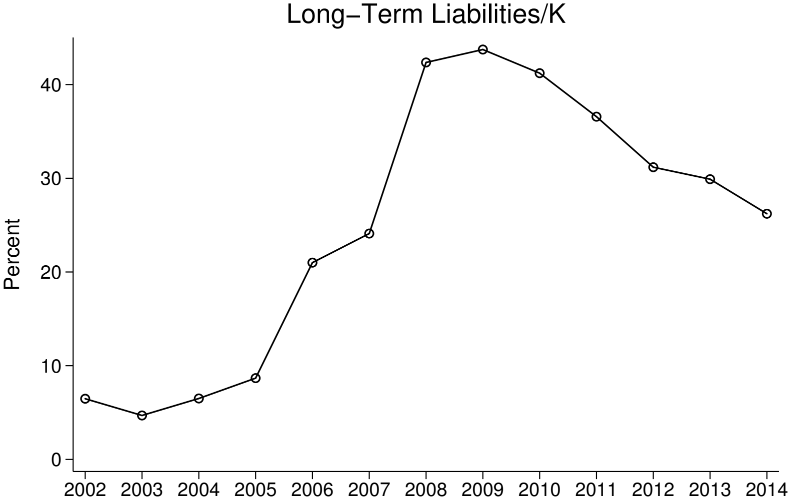
- The Rajan and Zingales (1998) variable $RZ = Med\left\{\frac{Inv-varProfit}{Inv}\right\}$ measures a sector dependence on external finance computed during the pre-crisis period
- Sectors that are **more dependent on external finance** were **more severely** affected by the crisis

The role of leverage - top tertile of the leverage distribution



The role of leverage - regressions

Model	*Logit Prb* $(y = 1\|x)$	$E(y\|x)$
Dep var	$\mathbb{I}\{\|I/K\| \leq 0.01\}$	log I
High LT leverage(2007 − 09)	0.15^{**}	-0.14^{**}
Controls, sector FE, time FE	yes	yes
N	8,131	6,385

- The dummy variable *High LT leverage*(2007 − 09) captures firms at the top tertile leverage (debt maturity > 1yr) during 2007-2009 and we restrict the sample to 2012–14 (the severe banking crisis years)

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- The dummy variable *High LT leverage*$(2007 - 09)$ captures firms at the top tertile leverage (debt maturity $>$ 1yr) during 2007-2009 and we restrict the sample to 2012–14 (the severe banking crisis years)
- Firms that entered the crisis with **highest leverage** had **lower investment** during the crisis

Stylized dynamic investment model with firm heterogeneity

In order to assess how a standard investment model explains the collapse of the investment we estimate a model similar to Cooper and Haltiwanger (2006):

$$K_{it+1} = (1-\delta) K_{it} + I_{it}$$

and firms with capital K_{it} and profitability ω_{it} can choose to invest or not:

$$V(K_{it}, \omega_{it}) = \max \left\{ V^a(K_{it}, \omega_{it}), V^i(K_{it}, \omega_{it}) \right\}$$

with

$$V^a(K_{it}, \omega_{it}) = \max_{I_{it} \neq 0} \{\Pi(K_{it}, \omega_{it}) - C(I_{it}, K_{it}, \omega_{it}) + \beta E_{\omega_{it}} [V(K_{it+1}, \omega_{it+1})]\}$$

$$V^i(K_{it}, \omega_{it}) = \Pi(K_{it}, \omega_{it}) + \beta E_{\omega_{it}} [V((1-\delta) K_{it}, \omega_{it+1})]$$

Functional forms

- Optimal variable profit:

$$\Pi\left(K_{it}, \omega_{it}\right) = \exp\left(\omega_{it}\right) K_{it}^{\beta_K}$$

- AR(1) profitability process:

$$\omega_{it} = \mu_\omega\left(1 - \rho\right) + \rho\omega_{it-1} + \nu_{it}, \quad \nu_{it} \sim N\left(0, \sigma_\nu\right)$$

- Capital adjustment cost (convex and non-convex):

$$C\left(I_{it}, K_{it}, \omega_{it}\right) = \begin{cases} I_{it} + F \cdot \Pi\left(K_{it}, \omega_{it}\right) + \gamma K_{it}\left(\frac{I_{it}}{K_{it}}\right)^2 & \text{if } \frac{I_{it}}{K_{it}} > 0 \\ 0 & \text{if } \frac{I_{it}}{K_{it}} = 0 \\ I_{it} + F \cdot \Pi\left(K_{it}, \omega_{it}\right) & \text{if } \frac{I_{it}}{K_{it}} < 0 \end{cases}$$

Estimates

- Firm problem may be decomposed into a static component and a dynamic component.
- Non-linear GMM estimator (as in Ackerberg, Caves, and Frazer, 2015) to obtain parameters of the profit function and profitability process (AR-1 shocks, sample selection bias). estimates
  - in line with the literature (Cooper and Haltiwanger, 2006)
- SMM using the observed initial conditions for (K_{it}, ω_{it}) during the pre-crisis period (2002-07) to generate investment moments: inaction $Pr\left(|I_{it}/K_{it}| \leq 0.01\right)$; spikes $Pr\left(|I_{it}/K_{it}| > 0.2\right)$; $stdev\left(I_{it}/K_{it}\right)$ moments

Sector	Estimates		
	F	γ	$Dist$
Food and beverages	.03	12.2	.002
Metal products	.02	8.7	.002
Whole manufacturing	.03	14.0	.002

- Estimates seem to describe well the investment distribution and are in line with other studies (eg. Merz and Yashiv, 2007)

Explaining the collapse of the average investment rate

With the implied policy function $I_{it} = f^{Inv}(K_{it}, \omega_{it}; F, \gamma)$ we evaluate the predicted fall in the investment rate between $t_0 = \{2002 - 07\}$ and $t_1 = \{2010 - 14\}$:

$$\Delta\left(\overline{I/K}\right) = E\left[\frac{f^{Inv}(K_{it_1}, \omega_{it_1}; F, \gamma)}{K_{it_1}}\right] - E\left[\frac{f^{Inv}(K_{it_0}, \omega_{it_0}; F, \gamma)}{K_{it_0}}\right]$$

Sector	profit (Δ%)	capital (Δ%)	Inv rate (Δpp)	
	Data	Data	Data	Simul
Food and beverages	12.7	-17.1	-5.2	1.8
Metal products	-37.6	-4.7	-7.6	-3.1
Whole manufacturing	-12.3	-3.5	**-4.9**	**-2.2**
mean abs error (8 sect)				4.0
root-mean-square error (8 sect)				4.3

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- The model cannot account for the observed fall in the investment rate (consistent with the reduced form evidence)
- For the *Food* sector, the increase in profit generates a predicted increase in the investment rate

Model of debt collateral constraints and banking crises

We introduce debt B_{it} in the model by following Khan and Thomas (2013), where firms face two additional constraints:

- non-equity finance:

$$D_{it} = \Pi(K_{it}, \omega_{it}) - C(I_{it}, K_{it}, \omega_{it}) + qB_{it+1} - B_{it} \geq 0$$

- collateral constraint:

$$B_{it+1} \leq \xi_t K_{it}$$

Where the collateral parameter $\xi_t \equiv \{\xi^{low}, \xi^{high}\}$ follows a Markov chain:

$$\Pi^{\xi} = \begin{bmatrix} p^{high} & 1 - p^{high} \\ 1 - p^{low} & p^{low} \end{bmatrix}$$

Model of debt collateral constraints and banking crises

Firms decide on whether to invest and on how much debt to carry to the next period:

$$V_0\left(K_{it}, B_{it}, \omega_{it}, \xi_t\right) = \max\left\{V^a\left(K_{it}, B_{it}, \omega_{it}, \xi_t\right), V^i\left(K_{it}, B_{it}, \omega_{it}, \xi_t\right)\right\}$$

with

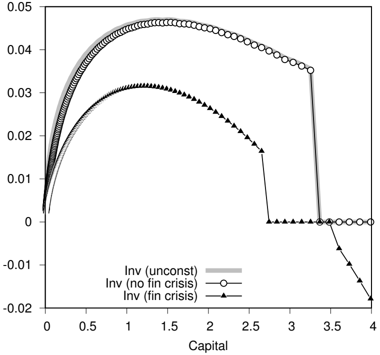
$$V^a\left(K_{it}, B_{it}, \omega_{it}, \xi_t\right) = \max_{I_{it}\neq 0, D_{it}, B_{it+1}} \left\{D_{it} - C\left(I_{it}, K_{it}, \omega_{it}\right) + \beta E_{\omega_{it}}\left[V\left(K_{it+1}, \omega_{it+1}, \xi_{t+1}\right)\right]\right\}$$

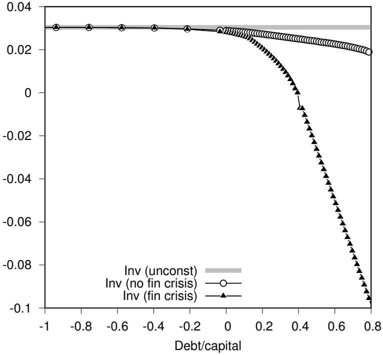
$$V^i\left(K_{it}, B_{it}, \omega_{it}, \xi_t\right) = \max_{D_{it}, B_{it+1}} \left\{D_{it} + \beta E_{\omega_{it}}\left[V\left((1-\delta) K_{it}, \omega_{it+1}, \xi_{t+1}\right)\right]\right\}$$

subject to the non-equity finance and collateral constraints

- The functional forms for profit $\Pi\left(K_{it}, \omega_{it}\right)$ and the capital adjustment costs $C\left(I_{it}, K_{it}, \omega_{it}\right)$ are the same as in the previous model

Investment policy functions under banking crisis





Calibration

parameters	values	comments
Profit function	same	Est from the entire period data
Profit process	same	Est from the entire period data
Capital adj cost	same	Est from the pre-crisis period data
Credit conditions	$\xi^{high} = 0.8$	90th pc lev for the pre-crisis period
	$\xi^{low} = 0.2$	match median drop in leverage
	$Prb(\xi^{high} \vert \xi^{high}) = 0.977$	Khan and Thomas (2013)
	$Prb(\xi^{low} \vert \xi^{low}) = 0.688$	Khan and Thomas (2013)

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- We use ξ^{high} to model a non-banking crisis environment and ξ^{low} for a banking crisis

Explaining the collapse of the average investment rate

With the implied policy investment function $I_{it} = g^{Inv}(K_{it}, B_{it}, \omega_{it}, \xi_{it})$ we assess if the model can explain the fall in the investment rate between $t_0 = \{2002...2007\}$ and $t_1 = \{2010...2014\}$:

$$\Delta\left(\overline{I/K}\right) = E\left[\frac{g^{Inv}(K_{it_1}, B_{it_1}, \omega_{it_1}, \xi_{t_1})}{K_{it_1}}\right] - E\left[\frac{g^{Inv}(K_{it_0}, B_{it_0}, \omega_{it_0}, \xi_{t_0})}{K_{it_0}}\right]$$

Sector	Data	Simul: Inv Rate (Δpp)		
	Inv Rate (Δpp)	no lev	no-bank crisis	bank crisis
		(counterfact)	(counterfact)	(calibrated)
Food and beverages	-5.2	1.8	1.8	-0.6
Metal products	-7.6	-3.1	-2.9	-6.5
Whole manufacturing	**-4.9**	-2.2	-1.9	**-4.7**
mean abs error (8 sectors)		4.0	4.1	2.6
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- Adding the observed leverage distribution at the beginning of 2010 and a banking crisis captures the investment rate fall (not targeting it directly)
- The model with credit constraints fits better the data

Understanding the mechanism

- Whited (1992) shows that financial frictions implies wedges in the investment decisions. From the problem first order conditions:

$$C_{K'}\left(K_{it+1}, K_{it}, \omega_{it}\right)\left(1+\lambda_{it}^{E}\right) = \beta E_t V_K\left(s_{it+1}\right)$$
$$-q\left(1+\lambda_{it}^{E}\right)+\lambda_{it}^{B} = \beta E_t V_B\left(s_{it+1}\right)$$

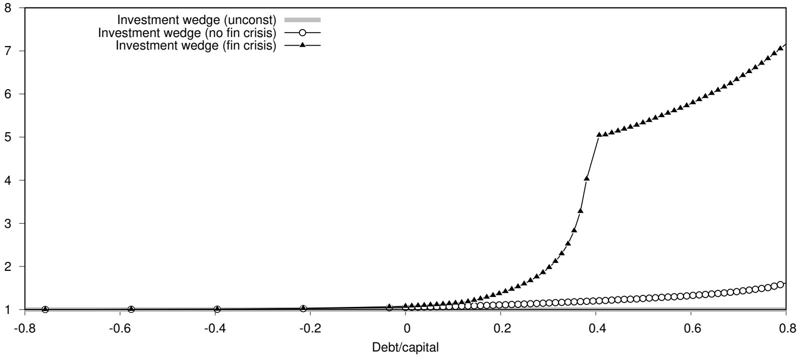
  which implies:

$$C_{K'}\left(K_{it+1}, K_{it}, \omega_{it}\right) = \beta \frac{E_t V_K\left(s_{it+1}\right)}{\lambda_{it}^{B}\beta^{-1} - E_t V_B\left(s_{it+1}\right)}$$

- The denominator of the the Euler equation can be interpreted as an investment wedge:

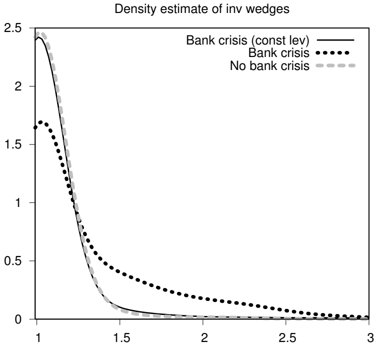
$$\Upsilon_{it} = \lambda_{it}^{B}\beta^{-1} - E_t V_B\left(s_{it+1}\right) \geq 1$$

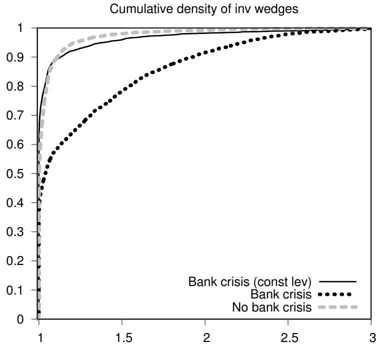
Investment wedge in the model



- investment wedge increases with leverage
- and is even larger under a banking crisis

Investment wedge in the simulations



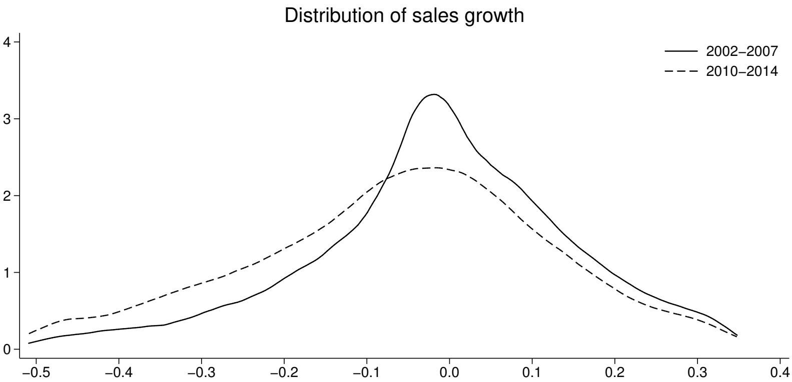


- a banking crisis implies a shift to the right of the investment wedges
- simulations imply an average effective discount factor of $\tilde{\beta} = \beta/\overline{\Upsilon}_{it} = 0.74$ relative to $\beta = 0.95$

Conclusions

- The Greek investment slump associated with the crisis cannot be explained only with variations in demand/productivity
  - model with only profitability shocks can account for less than half of the average investment rate fall
- Both a banking crisis and the firm level build up in leverage can match the observed fall in the investment rate:
  - despite the fact we don't target the investment rate directly
- Since both leverage and the banking crisis seem to be important to explain investment collapses during financial crises, policy implications may include:
  - Bank support during crisis periods
  - Macro prudential policies to avoid excessive leverage under normal periods

Sales growth distribution before and during the crisis



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Estimates of profitability: β_K, ρ, μ_ω, σ_ν

We use a non-linear GMM estimator similar to Ackerberg, Caves, and Frazer (2015) to obtain estimates for the profit function and profitability process:

Sector	Estimates of model parameters			
	β_K	ρ	μ_ω	σ_ν
Food and beverages	0.568	0.658	-0.622	0.649
Metal products	0.471	0.541	-1.045	0.745
Whole manufacturing	0.476	0.679	-0.801	0.666

- Estimates are in line with other studies in the literature (eg. Cooper and Haltiwanger, 2006) and display large heterogeneity of profitability

back

Dynamic estimates of adjustment costs: F, γ

We use SMM using the observed initial conditions for (K_{it}, ω_{it}) during the pre-crisis period (2002-07) to generate investment moments:

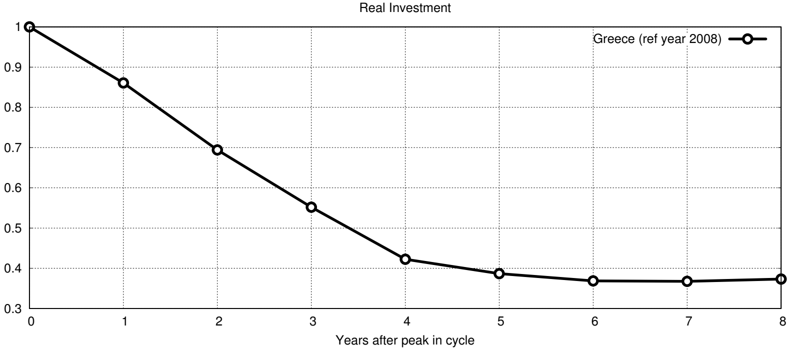
- inaction: $Pr\left(|I_{it}/K_{it}| \leq 0.01\right)$
- spikes: $Pr\left(|I_{it}/K_{it}| > 0.2\right)$
- standard deviation: $stdev\left(I_{it}/K_{it}\right)$:

Sector	Data moments			Model moments			Estimates		
	SD	Inac	Spike	SD	Inac	Spike	F	γ	$Dist$
Food and beverages	.25	.18	.16	.20	.18	.18	.03	12.2	.002
Metal products	.27	.21	.19	.22	.22	.21	.02	8.7	.002
Whole manufacturing	.26	.22	.17	.22	.22	.20	.03	14.0	.002

- Parameter estimates seem to describe well the cross sectional distribution of investment and are in line with other studies (eg. Merz and Yashiv, 2007)

back

The Greek crisis - aggregate investment



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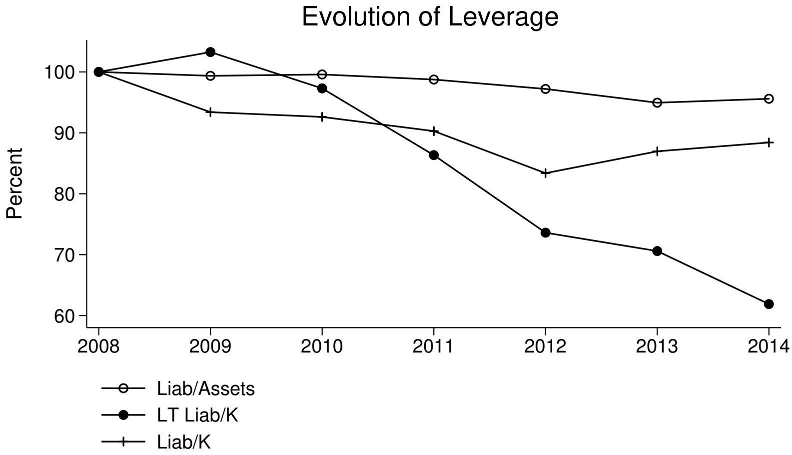
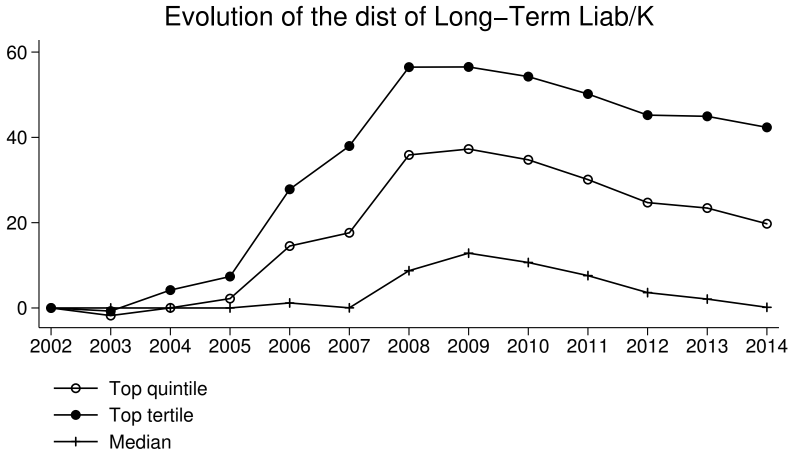
Different leverage measures



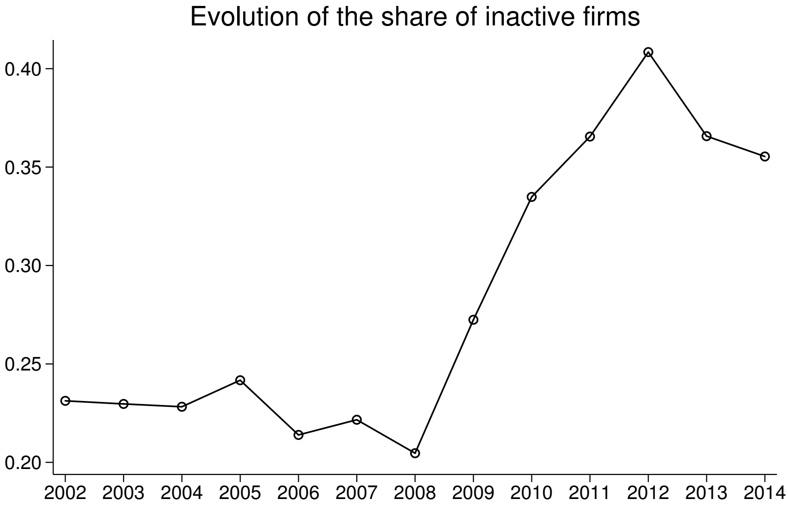
Variables normalized to 100 in 2008.
Statistic: top tertile of the leverage distribution. Source: EBE, ELSTAT

The leverage distribution across time



Variables normalized to 0 at their 2002 levels
Source: ELSTAT

Share of inactive firms



Summary statistics - production

Table: Summary Statistics of variables related to production

	p5	p10	p25	Med.	Mean	p75	p90	p95	IQR	SD
					2002-2007					
K	0.05	0.10	0.31	1.01	5.52	3.22	10.25	21.50	2.91	20.50
Sales	0.45	0.61	1.12	2.51	11.20	6.51	18.83	39.14	5.39	60.53
L	10.00	11.00	15.67	27.50	70.37	55.67	143.67	254.00	40.00	166.18
					2010-2014					
K	0.08	0.16	0.46	1.25	5.06	3.56	10.51	20.08	3.09	15.49
Sales	0.34	0.47	0.87	2.03	9.02	5.76	17.76	34.95	4.89	30.08
L	10.00	10.00	14.00	23.00	54.43	45.00	113.00	203.00	31.00	114.73
#Firms	5458									
#Obs.	14656									

Source: EBE, ELSTAT Variables are in 2010 euros. K is capital stock, Sales is manufacturing sales, L is number of employees. IQR is the interquartile range, SD is the sample standard deviation and and pXX is the XXth percentile of the distribution.

Summary statistics - leverage

Table: Leverage Evolution: All Manufacturing

	Long-Term Debt/K %	
Year	Median	Top tertile
2002	0.0	6.5
2003	0.0	4.7
2004	0.0	6.5
2005	0.0	8.7
2006	1.2	21.0
2007	0.0	24.1
2008	8.7	42.4
2009	12.9	43.7
2010	10.7	41.2
2011	7.6	36.6
2012	3.6	31.2
2013	2.1	29.9
2014	0.2	26.2

Source: ELSTAT Variables are in 2010 euros.