Sovereigns at Risk

A dynamic model of sovereign debt and banking leverage

Nuno Coimbra
Paris School of Economics

NBER ISOM, Bank of England
June, 2019

This paper

- **Novel theoretical framework to analyze how banking and government finances interact**

This paper

- **Novel theoretical framework to analyze how banking and government finances interact**
    - In particular: How bank regulation affects demand for sovereign bonds

This paper

- **Novel theoretical framework to analyze how banking and government finances interact**
  - In particular: How bank regulation affects demand for sovereign bonds
  - The model is calibrated to Spain and used to interpret recent bond yield movements

This paper

- **Novel theoretical framework to analyze how banking and government finances interact**
  - In particular: How bank regulation affects demand for sovereign bonds
  - The model is calibrated to Spain and used to interpret recent bond yield movements
  - Model can be used to measure the impact of recent ECB unconventional policies on sovereign bond yields

Contribution

- Dynamic macroeconomic model with sovereign default and a banking sector facing a Value-at-Risk constraint

Contribution

- Dynamic macroeconomic model with sovereign default and a banking sector facing a Value-at-Risk constraint
  - Feedback between bank balance sheet risk and sovereign yields

Contribution

- Dynamic macroeconomic model with sovereign default and a banking sector facing a Value-at-Risk constraint
  - Feedback between bank balance sheet risk and sovereign yields
  - Flexible framework that can be used as a workhorse model

Contribution

- Dynamic macroeconomic model with sovereign default and a banking sector facing a Value-at-Risk constraint
  - Feedback between bank balance sheet risk and sovereign yields
  - Flexible framework that can be used as a workhorse model
- Application: Long-Term Refinancing Operations (LTRO)
  - Quantify the effect of this type of central bank intervention in the presence of such feedback effects

Results

- Feedback effect leads to a 72% larger yield rise when the banking sector is not sufficiently capitalized

Results

- Feedback effect leads to a 72% larger yield rise when the banking sector is not sufficiently capitalized
  - Effect is larger in the presence of moral hazard
  - And more likely when other bank assets are performing poorly

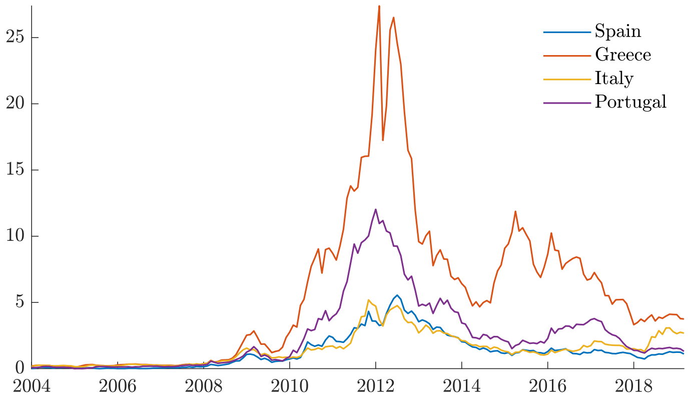
Results

- Feedback effect leads to a 72% larger yield rise when the banking sector is not sufficiently capitalized
  - Effect is larger in the presence of moral hazard
  - And more likely when other bank assets are performing poorly

- Central bank intervention can help dampen the feedback
  - Improve bank balance sheets
  - Reduce yields by restarting bank demand

Motivation

Bond spreads in the European Sovereign debt crisis



Source: ECB

Motivation

Long-Term Refinancing Operations

December 2011: The ECB announces a new unconventional policy called Long-Term Refinancing Operations (LTRO)

Motivation

Long-Term Refinancing Operations

December 2011: The ECB announces a new unconventional policy called Long-Term Refinancing Operations (LTRO)

- Massive liquidity injection into the banking system
    - More than EUR 1 trillion of funding
    - Two tranches: Dec 2011 and Feb 2012

Motivation

Long-Term Refinancing Operations

December 2011: The ECB announces a new unconventional policy called Long-Term Refinancing Operations (LTRO)

- Massive liquidity injection into the banking system
  - More than EUR 1 trillion of funding
  - Two tranches: Dec 2011 and Feb 2012
- Collateralized loans, up to 3 years maturity

Motivation

Long-Term Refinancing Operations

December 2011: The ECB announces a new unconventional policy called Long-Term Refinancing Operations (LTRO)

- Massive liquidity injection into the banking system
  - More than EUR 1 trillion of funding
  - Two tranches: Dec 2011 and Feb 2012
- Collateralized loans, up to 3 years maturity
  - Haircuts depended on type of asset, maturity and rating

Motivation

Long-Term Refinancing Operations

December 2011: The ECB announces a new unconventional policy called Long-Term Refinancing Operations (LTRO)

- Massive liquidity injection into the banking system
  - More than EUR 1 trillion of funding
  - Two tranches: Dec 2011 and Feb 2012
- Collateralized loans, up to 3 years maturity
  - Haircuts depended on type of asset, maturity and rating
- ECB waived rating requirements for EZ bonds

Commenting on the ECB's new unconventional policy

"[The LTRO] means that each state can turn to its banks, which will have liquidity at their disposal"

- Nicolas Sarkozy, Dec 15, 2011

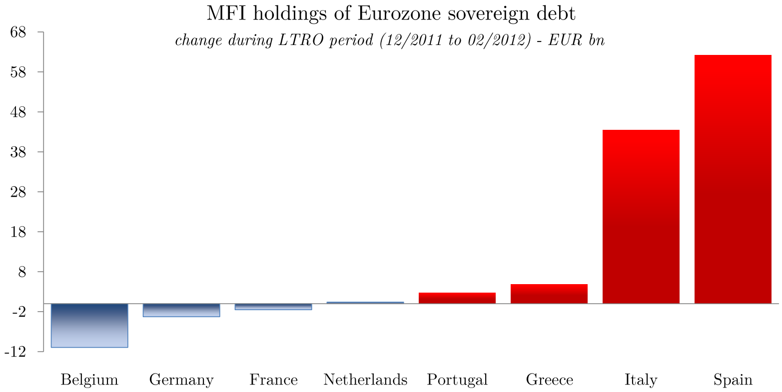
Commenting on the ECB's new unconventional policy

"[The LTRO] means that each state can turn to its banks, which will have liquidity at their disposal"

- Nicolas Sarkozy, Dec 15, 2011

This is how the LTRO came to be known as the Sarko-trade...

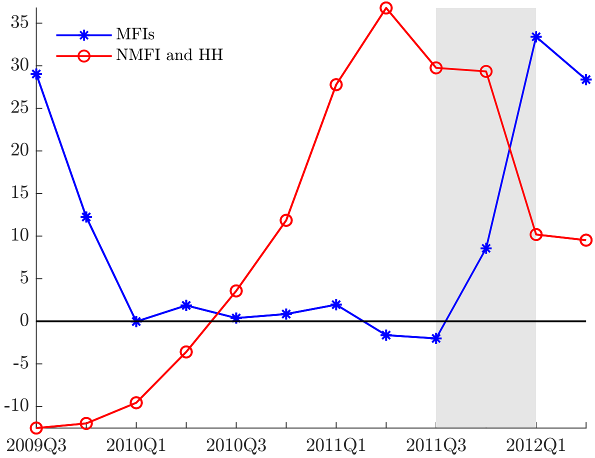
LTRO and bond purchases by domestic MFIs



Home Bias

Change in Spanish domestic bond holdings

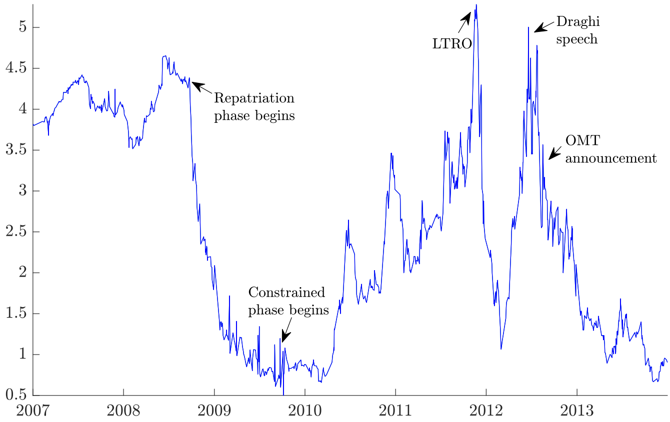
% change YoY in the share of holdings by sector



Source: Bank of Spain

RoW Italy

Spanish yields - 1 year maturity

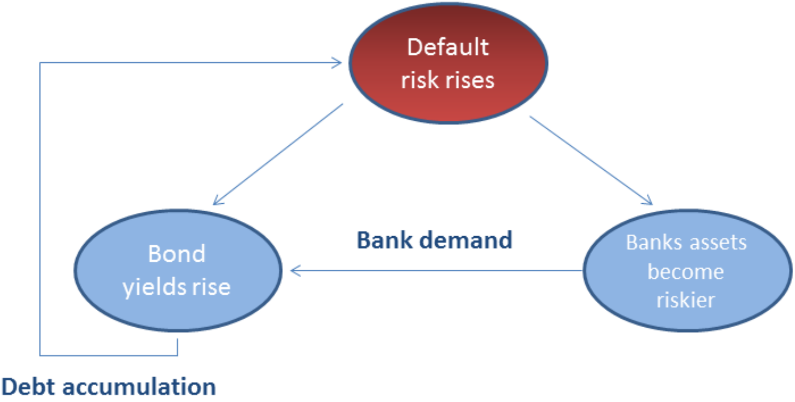


Source: Bank of Spain

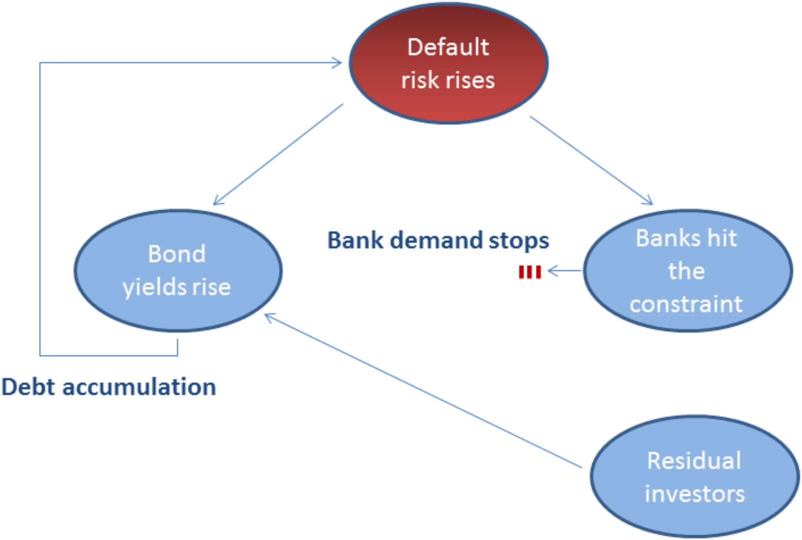
Table

The Mechanism

The Mechanism



The Mechanism



Literature

There are several strands of the literature to which the paper is related to:

- **Credit and Leverage Cycles**
  - Kiyotaki and Moore (1997), Bernanke et al. (1999), Gertler and Kiyotaki (2013),...
  - He and Krishnamurthy (2013), Brunnermeier and Sannikov (2013),...
  - Geanakoplos (2003,2010), Adrian and Shin (2010,2014), Adrian and Boyarchenko (2012), Coimbra and Rey (2019)

Literature

There are several strands of the literature to which the paper is related to:

- **Credit and Leverage Cycles**
  - Kiyotaki and Moore (1997), Bernanke et al. (1999), Gertler and Kiyotaki (2013),...
  - He and Krishnamurthy (2013), Brunnermeier and Sannikov (2013),...
  - Geanakoplos (2003,2010), Adrian and Shin (2010,2014), Adrian and Boyarchenko (2012), Coimbra and Rey (2019)
- **Government policy and default risk**
  - Eaton and Gersovitz (1981), Ruge-Murcia (1995,1999), Aguiar and Gopinath (2006), Arellano (2008), Bi and Leeper (2013),...

Literature

There are several strands of the literature to which the paper is related to:

- **Credit and Leverage Cycles**
  - Kiyotaki and Moore (1997), Bernanke et al. (1999), Gertler and Kiyotaki (2013),...
  - He and Krishnamurthy (2013), Brunnermeier and Sannikov (2013),...
  - Geanakoplos (2003,2010), Adrian and Shin (2010,2014), Adrian and Boyarchenko (2012), Coimbra and Rey (2019)
- **Government policy and default risk**
  - Eaton and Gersovitz (1981), Ruge-Murcia (1995,1999), Aguiar and Gopinath (2006), Arellano (2008), Bi and Leeper (2013),...
- **Sovereign default and banking**
  - Acharya et al. (2014), Gennaioli et al. (2013), Bocola (2016), Fahri and Tirole (2018),...

Basic Ingredients

The minimal requirements:

- Government debt dynamics with default risk

Basic Ingredients

The minimal requirements:

- Government debt dynamics with default risk
- At least 2 different types of investors

Basic Ingredients

The minimal requirements:

- Government debt dynamics with default risk
- At least 2 different types of investors
  - Different willingness to pay for risky assets

Basic Ingredients

The minimal requirements:

- Government debt dynamics with default risk
- At least 2 different types of investors
    - Different willingness to pay for risky assets

Specifically used:

- Government capable of default (Bi and Leeper 2013, Bi 2012)

Basic Ingredients

The minimal requirements:

- Government debt dynamics with default risk
- At least 2 different types of investors
  - Different willingness to pay for risky assets

Specifically used:

- Government capable of default (Bi and Leeper 2013, Bi 2012)
- Households as residual investor and banks
  - Households price bonds with the standard SDF
  - Banks are Value-at-Risk investors (Adrian and Shin 2010)

Households

- King-Plosser-Rebelo preferences
  - Risk averse
  - Derive utility from consumption C_t and leisure L_t

Households

- King-Plosser-Rebelo preferences
    - Risk averse
    - Derive utility from consumption C_t and leisure L_t
- Save in the form of deposits D_t and/or sovereign bonds B_t^H
    - Short-selling constraint on sovereign bonds

Households

- King-Plosser-Rebelo preferences
  - Risk averse
  - Derive utility from consumption C_t and leisure L_t
- Save in the form of deposits D_t and/or sovereign bonds B_t^H
  - Short-selling constraint on sovereign bonds
- Labour income is subject to the proportional tax rate τ_t.

Households

- King-Plosser-Rebelo preferences
  - Risk averse
  - Derive utility from consumption C_t and leisure L_t
- Save in the form of deposits D_t and/or sovereign bonds B_t^H
  - Short-selling constraint on sovereign bonds
- Labour income is subject to the proportional tax rate τ_t.
- Receive gov transfers $\tilde{Z}_t$ and financial sector dividends Π_t^B

The maximization program

$$\max \mathbb{E}_t \left[\sum_{t=0}^{\infty} \beta^t u(C_t, L_t) \right]$$

subject to:

$$C_t + q_t^D D_t + q_t^B B_t^H = w_t(1-\tau_t) + \tilde{Z}_t + D_{t-1} + (1-\Delta_t) B_{t-1}^H + \Pi_t^B$$
$$B_t^H \geq 0$$

Utility function FOCs

Production

$$Y_t = A_t(1 - L_t)$$

Production

$$Y_t = A_t(1 - L_t)$$

Labour productivity A_t follows:

$$\log A_t = \rho^a \log A_{t-1} + \varepsilon_t^a$$
$$\varepsilon^a \sim N(0, \sigma_a^2)$$

Representative bank

- Risk neutral, profit maximizing

The Model

The Banking sector

Representative bank

- Risk neutral, profit maximizing
- Subject to a Value-at-Risk constraint

Representative bank

- Risk neutral, profit maximizing
- Subject to a Value-at-Risk constraint
- Funded by inside equity E_t and household deposits D_t.

Representative bank

- Risk neutral, profit maximizing
- Subject to a Value-at-Risk constraint
- Funded by inside equity E_t and household deposits D_t.
- Invests in sovereign bonds B_t^B.

The Value-at-Risk constraint

- Bank cannot have a probability of default higher than α

The Value-at-Risk constraint

- Bank cannot have a probability of default higher than α
- Links portfolio risk to adequate capitalization and leverage

How does it work? | Leverage Cycle | Other constraints | Data

The Model

The Banking sector

The Value-at-Risk constraint

- Bank cannot have a probability of default higher than α
- Links portfolio risk to adequate capitalization and leverage

How does it work? | Leverage Cycle | Other constraints | Data

$\Rightarrow$ *Close mapping to stress testing*

- Stress test: resilience to probabilistic stress scenario

The Value-at-Risk constraint

- Bank cannot have a probability of default higher than α
- Links portfolio risk to adequate capitalization and leverage

How does it work? Leverage Cycle Other constraints Data

$\Rightarrow$ *Close mapping to stress testing*

- Stress test: resilience to probabilistic stress scenario
- Focuses on the lower tail of portfolio return distribution

The Model

The Banking sector

The Value-at-Risk constraint

- Bank cannot have a probability of default higher than α
- Links portfolio risk to adequate capitalization and leverage

How does it work? Leverage Cycle Other constraints Data

$\Rightarrow$ *Close mapping to stress testing*

- Stress test: resilience to probabilistic stress scenario
- Focuses on the lower tail of portfolio return distribution
- First EU-wide stress test of "constrained phase", was the first ever to consider an "adverse sovereign risk shock"

Adverse scenario

The banking sector

The bank's balance sheet

The bank's balance sheet during period t:

Assets	Liabilities
$q_t^B B_t^B$	E_t
	$q_t^D D_t$

The banking sector

The bank's balance sheet

The bank's balance sheet during period t:

Assets	Liabilities
$q_t^B B_t^B$	E_t
	$q_t^D D_t$

Asset payoffs at the beginning of $t+1$:

$$\begin{aligned} \text{Receive: } & B_t^B(1-\Delta_{t+1}) \\ \text{Must pay: } & D_t \end{aligned}$$

The banking sector

Banks maximize expected profits $E(\Pi^B_{t+1})$, where

$$\Pi^B_{t+1} = B^B_t(1 - \Delta_{t+1}) - D_t$$

- Subject to the VaR constraint

$$Prob(D_t > (1 - \Delta_{t+1})B^B_t) \leq \alpha$$

The banking sector

Banks maximize expected profits $E(\Pi^B_{t+1})$, where

$$\Pi^B_{t+1} = B^B_t(1 - \Delta_{t+1}) - D_t$$

- Subject to the VaR constraint

$$Prob(D_t > (1 - \Delta_{t+1})B^B_t) \leq \alpha$$

$\Rightarrow$ probability that bank defaults must be lower than α

The banking sector

The Value-at-Risk constraint

When binding, the VaR constraint implies that:

$$Prob\left(\Delta_{t+1} > 1 - \frac{D_t}{B_t^B}\right) = \alpha$$

The banking sector

The Value-at-Risk constraint

When binding, the VaR constraint implies that:

$$Prob\left(\Delta_{t+1} > 1 - \frac{D_t}{B_t^B}\right) = \alpha$$

Define leverage $\Lambda_t \equiv \frac{q_t^B B_t^B}{E_t}$, as market value of assets over equity.

The banking sector
The Value-at-Risk constraint

When binding, the VaR constraint implies that:

$$Prob\left(\Delta_{t+1} > 1 - \frac{D_t}{B_t^B}\right) = \alpha$$

Define leverage $\Lambda_t \equiv \frac{q_t^B B_t^B}{E_t}$, as market value of assets over equity.

$$\Pr\left(\Delta_{t+1} > 1 - \frac{q_t^B}{q_t^D}\frac{\Lambda_t - 1}{\Lambda_t}\right) = \alpha$$

The banking sector

The Value-at-Risk constraint

When binding, the VaR constraint implies that:

$$Prob\left(\Delta_{t+1} > 1 - \frac{D_t}{B_t^B}\right) = \alpha$$

Define leverage $\Lambda_t \equiv \frac{q_t^B B_t^B}{E_t}$, as market value of assets over equity.

$$\Pr\left(\Delta_{t+1} > 1 - \frac{q_t^B}{q_t^D}\frac{\Lambda_t - 1}{\Lambda_t}\right) = \alpha$$

Given q_t^B, q_t^D and the cdf $F(\Delta_{t+1})$:

- LHS expression is monotonic in Λ_t
- Unique solution: $\overline{\Lambda}_t$

The banking sector

Maximum leverage

Maximum leverage $\overline{\Lambda}_t$ is state-dependent.

- Default expectations crucial
- Also a function of asset prices

The banking sector

Maximum leverage

Maximum leverage $\overline{\Lambda}_t$ is state-dependent.

- Default expectations crucial
- Also a function of asset prices

When constraint is not binding

- Banks absorb all debt $B_t^B = B_t$
- Leverage $\Lambda_t = \frac{B_t}{E_t} \leq \overline{\Lambda}_t$
- Risk averse households only save using deposits

The role of the marginal investor

When probability of default is low, banks are unconstrained

$$q_t^{B,u} = q_t^D \mathbb{E}_t(1 - \Delta_{t+1})$$

Moral Hazard

$$q_t^{B,u} = \beta \mathbb{E}_t \left[\frac{u'_{C,t+1}}{u'_{C,t}} \right] \mathbb{E}_t(1 - \Delta_{t+1})$$

The role of the marginal investor

When probability of default is low, banks are unconstrained

$$q_t^{B,u} = q_t^D \mathbb{E}_t(1 - \Delta_{t+1})$$

Moral Hazard

$$q_t^{B,u} = \beta \mathbb{E}_t \left[\frac{u'_{C,t+1}}{u'_{C,t}} \right] \mathbb{E}_t(1 - \Delta_{t+1})$$

But when high, they can be constrained

$$q_t^{B,c} = \beta \mathbb{E}_t \left[\frac{u'_{C,t+1}}{u'_{C,t}} (1 - \Delta_{t+1}) \right]$$

The role of the marginal investor

When probability of default is low, banks are unconstrained

$$q_t^{B,u} = q_t^D \mathbb{E}_t(1 - \Delta_{t+1})$$

Moral Hazard

$$q_t^{B,u} = \beta \mathbb{E}_t \left[\frac{u'_{C,t+1}}{u'_{C,t}} \right] \mathbb{E}_t(1 - \Delta_{t+1})$$

But when high, they can be constrained

$$q_t^{B,c} = \beta \mathbb{E}_t \left[\frac{u'_{C,t+1}}{u'_{C,t}} (1 - \Delta_{t+1}) \right]$$

$\Rightarrow$ Since households are risk averse, there is a risk premium

$$q_t^{B,c} < q_t^{B,u}$$

How to model the probability of default/expected haircuts?

How to model the probability of default/expected haircuts?

Desired properties:

1. Counter-cyclicality
2. Increases with Debt/GDP ratio and size of yields
3. Increases with future expenditure needs
4. Falls with ability to tax

How to model the probability of default/expected haircuts?

Desired properties:

1. Counter-cyclicality
2. Increases with Debt/GDP ratio and size of yields
3. Increases with future expenditure needs
4. Falls with ability to tax

Chosen: Similar approach to Bi and Leeper (2013) and Bi (2012).

The Government

Government requires funding for:

- Expenditures G_t
- Transfers Z_t

The Government

Government requires funding for:

- Expenditures G_t
- Transfers Z_t

Expenditures are procyclical and follow:

$$\log G_t = (1-\rho^G)\log \bar{G} + \rho^G \log G_{t-1} + \varepsilon_t^G$$
$$\varepsilon^G \sim N(0, \sigma_g^2)$$

The Government

Transfers

Transfers can enter periods of unsustainable growth.

- (e.g. a delay in social security reforms)

The Government

Transfers

Transfers can enter periods of unsustainable growth.

- (e.g. a delay in social security reforms)

Markov switching process with 2 regimes:

$$\log Z_t \equiv \begin{cases} \log \bar{Z} + \alpha^Z \log A_t & s_t^z = 0 \\ \mu^z + \log Z_{t-1} + \alpha^z \log A_t & s_t^z = 1 \end{cases}$$

The Government

Transfers

Transfers can enter periods of unsustainable growth.

- (e.g. a delay in social security reforms)

Markov switching process with 2 regimes:

$$\log Z_t \equiv \begin{cases} \log \bar{Z} + \alpha^Z \log A_t & s_t^z = 0 \\ \mu^z + \log Z_{t-1} + \alpha^z \log A_t & s_t^z = 1 \end{cases}$$

- Regime s_t^z evolves according to transition matrix P^z
- μ^z measures the explosiveness of the non-stationary regime
- α^z measures (counter) cyclicality.

The Government

Revenues

Main source of funding is a labour income tax:

$$T_t^W = \tau_t A_t (1 - L_t)$$

The Government
Revenues

Main source of funding is a labour income tax:

$$T_t^W = \tau_t A_t (1 - L_t)$$

where τ_t is set under a feedback rule

$$\tau_t - \bar{\tau} = \xi (B_{t-1} - \bar{B})$$

The Government

Revenues

Main source of funding is a labour income tax:

$$T_t^W = \tau_t A_t (1 - L_t)$$

where τ_t is set under a feedback rule

$$\tau_t - \bar{\tau} = \xi (B_{t-1} - \bar{B})$$

- τ increases when debt is high and decreases when low
- ξ is the elasticity of τ w.r.t B_t

The Government

Laffer curve and fiscal limit distribution

Distortionary tax on labour

- Laffer curve effect: $\nearrow$ taxes $\Rightarrow$ $\searrow$ net wages $\Rightarrow$ $\searrow$ output

The Government

Laffer curve and fiscal limit distribution

Distortionary tax on labour

- Laffer curve effect: $\nearrow$ taxes $\Rightarrow$ $\searrow$ net wages $\Rightarrow$ $\searrow$ output
- $\exists \tau^{max}$ that maximizes tax revenue

The Government

Laffer curve and fiscal limit distribution

Distortionary tax on labour

- Laffer curve effect: $\nearrow$ taxes $\Rightarrow$ $\searrow$ net wages $\Rightarrow$ $\searrow$ output
- $\exists \tau^{max}$ that maximizes tax revenue
- Use this property to generate fiscal limit distribution

The Government

Laffer curve and fiscal limit distribution

Distortionary tax on labour

- Laffer curve effect: $\nearrow$ taxes $\Rightarrow$ $\searrow$ net wages $\Rightarrow$ $\searrow$ output
- $\exists \tau^{max}$ that maximizes tax revenue
- Use this property to generate fiscal limit distribution
- For every point in the state space, find distribution of present value of future maximal fiscal surpluses.

$$\mathcal{B}^*(A_t, G_t, Z_t, s_t^z) \sim \sum_{j=0}^{\infty} \beta \frac{u'_{C_{t+j}^{max}}}{u'_{C_t^{max}}} \left(\tau_t^{max} A_{t+j}(1 - L_{t+j}^{max}) - G_{t+j} - Z_{t+j}\right)$$

Default probabilities

$\mathcal{B}_t = \mathcal{B}^*(B^*|A_t, G_t, Z_t, s_t^z)$ is the conditional distribution of the present value of maximal future surpluses (B^*) across all possible future paths

Default probabilities

$\mathcal{B}_t = \mathcal{B}^*(B^* | A_t, G_t, Z_t, s_t^z)$ is the conditional distribution of the present value of maximal future surpluses (B^*) across all possible future paths

- Default probability is equal to the probability measure of paths for which $B^* < B_t$

Default probabilities

$\mathcal{B}_t = \mathcal{B}^*(B^*|A_t, G_t, Z_t, s_t^z)$ is the conditional distribution of the present value of maximal future surpluses (B^*) across all possible future paths

- Default probability is equal to the probability measure of paths for which $B^* < B_t$
    - If 3% are lower than current debt B_t, then $\pi_t^{default} = 3\%$

Default probabilities

$\mathcal{B}_t = \mathcal{B}^*(B^* | A_t, G_t, Z_t, s_t^z)$ is the conditional distribution of the present value of maximal future surpluses (B^*) across all possible future paths

- Default probability is equal to the probability measure of paths for which $B^* < B_t$
  - If 3% are lower than current debt B_t, then $\pi_t^{default} = 3\%$
- Default probabilities are time-varying and state-dependent

Default probabilities

$\mathcal{B}_t = \mathcal{B}^*(B^*|A_t, G_t, Z_t, s_t^z)$ is the conditional distribution of the present value of maximal future surpluses (B^*) across all possible future paths

- Default probability is equal to the probability measure of paths for which $B^* < B_t$
    - If 3% are lower than current debt B_t, then $\pi_t^{default} = 3\%$
- Default probabilities are time-varying and state-dependent
- Depend on expectations about transfer regime in the future
    - Even at the stable regime, high debt levels can lead to default
    - Some future paths enter the explosive regime

Default episodes

What happens during sovereign default?

Default episodes

What happens during sovereign default?

- Temporary output loss during default years

Default episodes

What happens during sovereign default?

- Temporary output loss during default years
- Haircut Δ_t is drawn randomly from estimated distribution

Default episodes

What happens during sovereign default?

- Temporary output loss during default years
- Haircut Δ_t is drawn randomly from estimated distribution
- In the event of a banking crisis, deposit guarantees are senior to bonds.

Default episodes

What happens during sovereign default?

- Temporary output loss during default years
- Haircut Δ_t is drawn randomly from estimated distribution
- In the event of a banking crisis, deposit guarantees are senior to bonds.
- If banks default, the government recapitalizes them

Default episodes

What happens during sovereign default?

- Temporary output loss during default years
- Haircut Δ_t is drawn randomly from estimated distribution
- In the event of a banking crisis, deposit guarantees are senior to bonds.
- If banks default, the government recapitalizes them
  - To fund this the government may need to reduce transfers to households.

Default episodes

What happens during sovereign default?

- Temporary output loss during default years
- Haircut Δ_t is drawn randomly from estimated distribution
- In the event of a banking crisis, deposit guarantees are senior to bonds.
- If banks default, the government recapitalizes them
  - To fund this the government may need to reduce transfers to households.
  - Seniority structure: Deposit guarantees most senior, followed by transfer liabilities and then sovereign bonds

Bond yields

- Bond yields depend endogenously on
  - The probability of sovereign default
  - The expected size of the haircut (Δ)
  - The identity of the marginal buyer

Bond yields

- Bond yields depend endogenously on
  - The probability of sovereign default
  - The expected size of the haircut (Δ)
  - The identity of the marginal buyer

- If the probability of default is zero
  - Bond is risk-free and $q_t^B = q_t^D$
  - Else $q_t^B < q_t^D$, so implied yield>deposit rates

Bond yields

Small yield differences can be amplified:

Bond yields

Small yield differences can be amplified:

- Rolling over debt
  - Lower $q_t^B \Rightarrow$ higher $B_t \Rightarrow$ higher $\mathbb{E}(\Delta_{t+1}) \Rightarrow$ lower q_t^B

Bond yields

Small yield differences can be amplified:

- Rolling over debt
  - Lower $q_t^B \Rightarrow$ higher $B_t \Rightarrow$ higher $\mathbb{E}(\Delta_{t+1}) \Rightarrow$ lower q_t^B
- Laffer curve effect
  - Higher $B_t \Rightarrow$ higher $\mathbb{E}(\tau_{t+1}) \Rightarrow$ lower $\mathbb{E}(Y_{t+1})$

Bond yields

Small yield differences can be amplified:

- Rolling over debt
  - Lower $q_t^B \Rightarrow$ higher $B_t \Rightarrow$ higher $\mathbb{E}(\Delta_{t+1}) \Rightarrow$ lower q_t^B
- Laffer curve effect
  - Higher $B_t \Rightarrow$ higher $\mathbb{E}(\tau_{t+1}) \Rightarrow$ lower $\mathbb{E}(Y_{t+1})$
- Dynamic effect
  - Even if no default at $t+1$
  - Higher $B_t \Rightarrow$ higher $\mathbb{E}(B_{t+1})$

Numerical analysis

Calibration

Parameter	Value	Description
γ	4	Standard risk aversion value
ϕ	1.2183	match steady-state leisure at 0.6
β	0.973	match Spain's average deposit rate
ρ^a	0.817	Fitted from EU KLEMS data
σ_a	0.019	Fitted from EU KLEMS data
$\bar{G}$	18.45%	Government consumption spending (% of GDP)
ρ^G	0.952	Fitted from the data used for $\bar{G}$
σ_G	0.012	Fitted from the data used for $\bar{G}$
$\bar{Z}$	14.39%	Average social security funds (% of GDP)
μ_z	1.02	Average growth in social security (% of GDP)
$\bar{B}/\bar{Y}$	60%	Target level of debt set to Stability and Growth Pact level
$\bar{E}/\bar{Y}$	23%	Book equity over GDP of MFIs in Spain

Sovereign default risk

What happens if default risk increases?

- Endogenous!

Sovereign default risk

What happens if default risk increases?

- Endogenous!
- Shock to government transfer policy
    - Regime switches to explosive for 10 periods

Sovereign default risk

What happens if default risk increases?

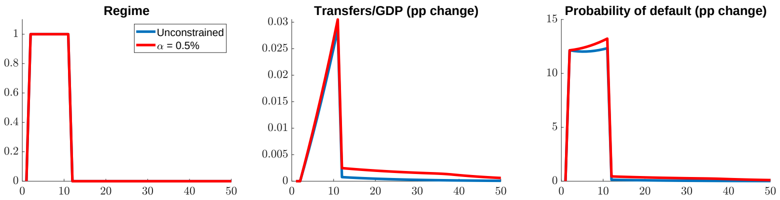
- Endogenous!
- Shock to government transfer policy
  - Regime switches to explosive for 10 periods
  - Length of regime is not known ex-ante

Sovereign default risk

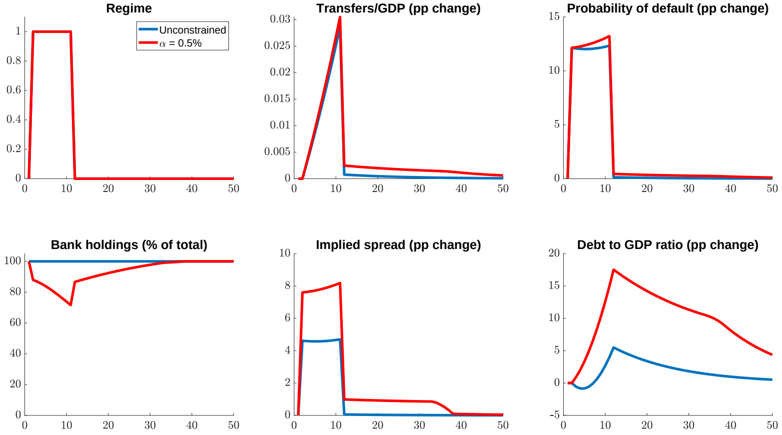
What happens if default risk increases?

- Endogenous!
- Shock to government transfer policy
  - Regime switches to explosive for 10 periods
  - Length of regime is not known ex-ante
  - Government doesn't default during this period

Fiscal regime shock

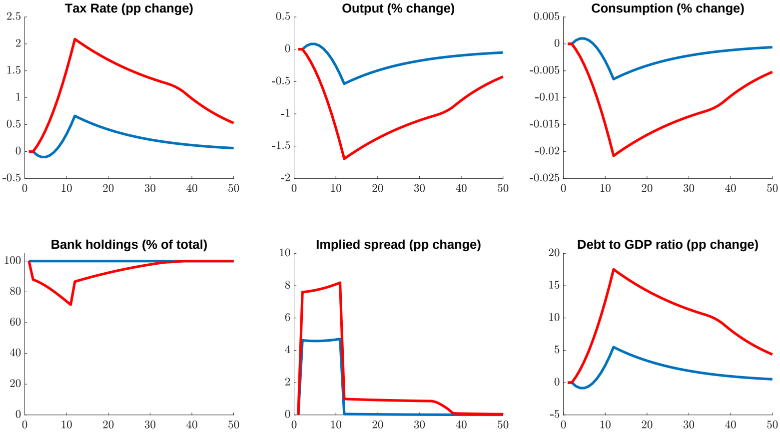


Fiscal regime shock



Regime switching shock lasting 10 periods

Fiscal regime shock



Regime switching shock lasting 10 periods

Extensions

The framework is sufficiently flexible to accommodate

- Additional assets Go
- Moral Hazard Go
- Application: LTRO and Spain Go

Conclusion

Conclusion

- New theoretical framework to study interactions between banking and government finances

Conclusion

- New theoretical framework to study interactions between banking and government finances
  - Interdependence between banking sector capitalization and debt sustainability

Conclusion

- New theoretical framework to study interactions between banking and government finances
  - Interdependence between banking sector capitalization and debt sustainability
  - Amplification mechanism due to insufficient capital in the banking sector

Conclusion

- New theoretical framework to study interactions between banking and government finances
  - Interdependence between banking sector capitalization and debt sustainability
  - Amplification mechanism due to insufficient capital in the banking sector
  - Short-term yield differences can generate significant and persistent increases in Debt/GDP ratios

Conclusion

- New theoretical framework to study interactions between banking and government finances
  - Interdependence between banking sector capitalization and debt sustainability
  - Amplification mechanism due to insufficient capital in the banking sector
  - Short-term yield differences can generate significant and persistent increases in Debt/GDP ratios
- Unconventional monetary policy intervention
  - Helps restore bank balance sheets
  - Strong impact on yields if bank demand is restarted

Conclusion

Thank you!

Long-Term Refinancing Operations

Long-Term Refinancing Operations (LTRO)

- The model's bank balance sheet becomes

Assets	Liabilities
$q_t^B B_t^B$	E_t
	$q_t^{LTRO} F_t$
	$q_t^D D_t$

Long-Term Refinancing Operations

Long-Term Refinancing Operations (LTRO)

- The model's bank balance sheet becomes

Assets	Liabilities
$q_t^B B_t^B$	E_t
	$q_t^{LTRO} F_t$
	$q_t^D D_t$

- If $q_t^{LTRO} > q_t^D$ then they can expand asset side

Long-Term Refinancing Operations

Long-Term Refinancing Operations (LTRO)

- The model's bank balance sheet becomes

Assets	Liabilities
$q_t^B B_t^B$	E_t
	$q_t^{LTRO} F_t$
	$q_t^D D_t$

- If $q_t^{LTRO} > q_t^D$ then they can expand asset side
- Policy tool to return marginal buyer status to banks

Long-Term Refinancing Operations

The constraint may be counterproductive in a crisis

- Governments would like to relax constraint in such times
- However, regulation is often "sticky"...

Long-Term Refinancing Operations

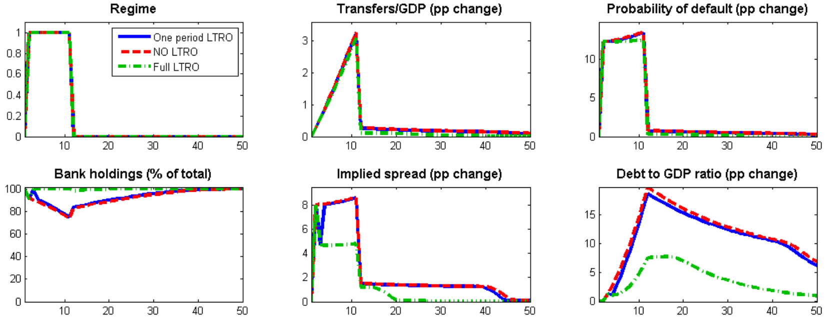
The constraint may be counterproductive in a crisis

- Governments would like to relax constraint in such times
- However, regulation is often "sticky"...

LTRO to the rescue!

- By providing cheaper funding banks are able to lever up
- Similar to increasing α

Long-Term Refinancing Operations



Back to extensions

Moral Hazard

- In the presence of limited liability or deposit guarantees, unconditional expected returns are not equalized

Moral Hazard

- In the presence of limited liability or deposit guarantees, unconditional expected returns are not equalized
  - Return on equity is truncated at zero: option value of default

Moral Hazard

- In the presence of limited liability or deposit guarantees, unconditional expected returns are not equalized
  - Return on equity is truncated at zero: option value of default
  - $\overline{\Delta}_t \equiv$ largest haircut at t+1 that doesn't default the bank

Moral Hazard

- In the presence of limited liability or deposit guarantees, unconditional expected returns are not equalized
    - Return on equity is truncated at zero: option value of default
    - $\overline{\Delta}_t \equiv$ largest haircut at t+1 that doesn't default the bank

$$q_t^{B,u} = q_t^D F_t\left(\overline{\Delta}_t\right)\left(1 - \mathbb{E}_t\left[\Delta_{t+1} | \Delta_{t+1} < \overline{\Delta}_t\right]\right)$$

Moral Hazard

- In the presence of limited liability or deposit guarantees, unconditional expected returns are not equalized
  - Return on equity is truncated at zero: option value of default
  - $\overline{\Delta}_t \equiv$ largest haircut at t+1 that doesn't default the bank

$$q_t^{B,u} = q_t^D F_t\left(\overline{\Delta}_t\right)\left(1 - \mathbb{E}_t\left[\Delta_{t+1} | \Delta_{t+1} < \overline{\Delta}_t\right]\right)$$

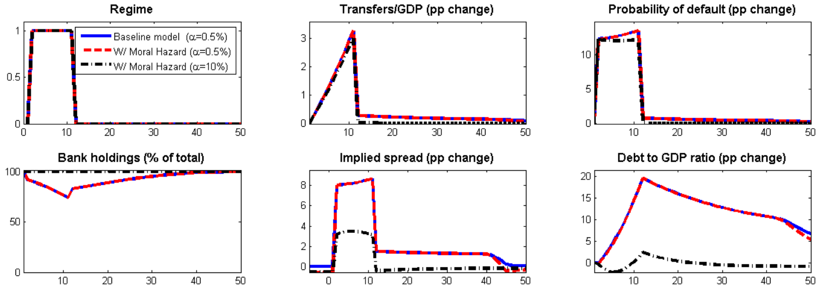
$$\text{where} \quad \overline{\Delta}_t \equiv 1 - \frac{q_t^B}{q_t^D}\frac{\Lambda_t - 1)}{\Lambda_t}$$

$$F_t\left(\Delta\right) = 1 - \pi_t^D + \pi_t^D \Omega(\Delta)$$

$$\mathbb{E}_t\left[\Delta_{t+1} | \Delta_{t+1} < \overline{\Delta}\right] = \frac{\int_0^{\overline{\Delta}_t} \Delta dF_t(\Delta)}{F_t(\overline{\Delta}_t)}$$

Back to main
Back to extensions

Moral Hazard



Regime switching shock lasting 10 periods

Back to main
Back to extensions

Additional assets

The bank's balance sheet

The bank's balance sheet during period t:

Assets	Liabilities
$q_t^F F_t^B$	E_t
$q_t^B B_t^B$	$q_t^D D_t$

Additional assets

The bank's balance sheet

The bank's balance sheet during period t:

Assets	Liabilities
$q_t^F F_t^B$	E_t
$q_t^B B_t^B$	$q_t^D D_t$

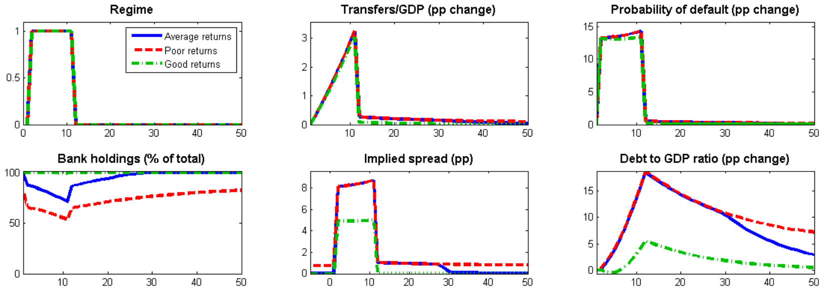
- Assuming sequential trading:

Assets	Liabilities
$q_t^B B_t^B$	$\tilde{E}_t$
	$q_t^D D_t$

- $\tilde{E}_t = E_t + F_t^B R_t^F - q_t^F F_t^B$

Back to extensions

Additional assets



Regime switching shock lasting 10 periods

Back to extensions

Value-at-Risk

The role of default

- If return on assets is too low, the bank might not be able to repay its liabilities.

Value-at-Risk

The role of default

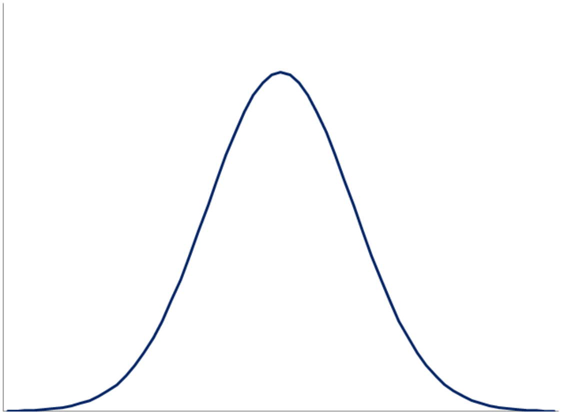
- If return on assets is too low, the bank might not be able to repay its liabilities.

Equity serves as a cushion. The more capitalized a bank is:

- The bigger the losses the bank can absorb
- The lower its probability of default for a given portfolio

Value-at-Risk

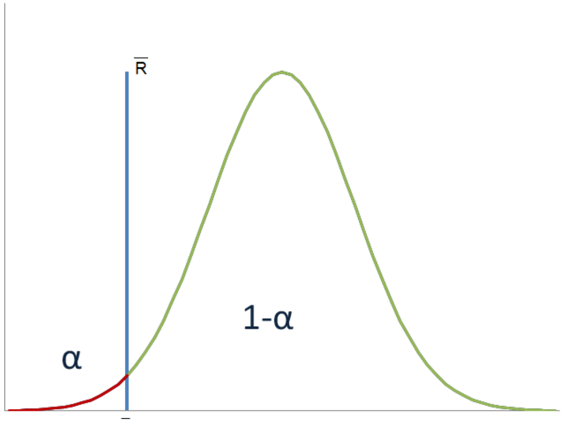
A simple portfolio return distribution:



Back

Value-at-Risk

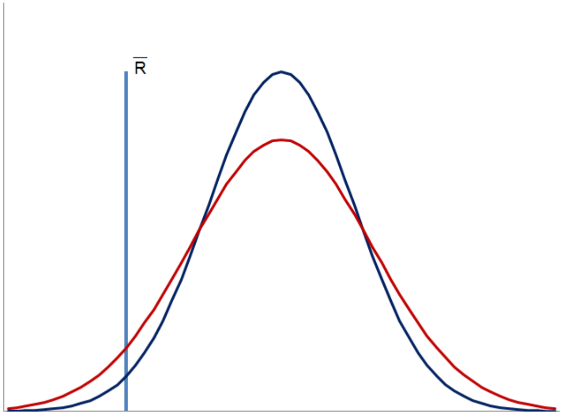
Given equity and leverage



Back

Value-at-Risk

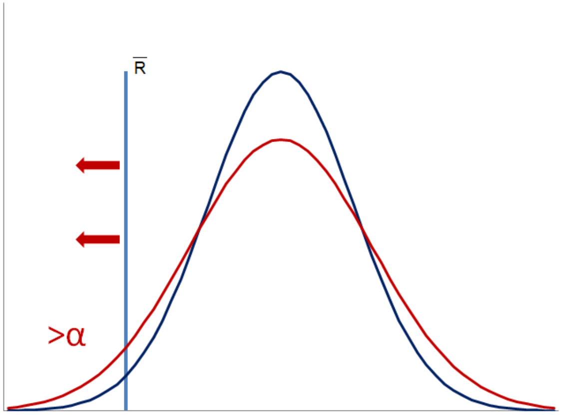
What if portfolio risk goes up?



Back

Value-at-Risk

What if portfolio risk goes up?



Back

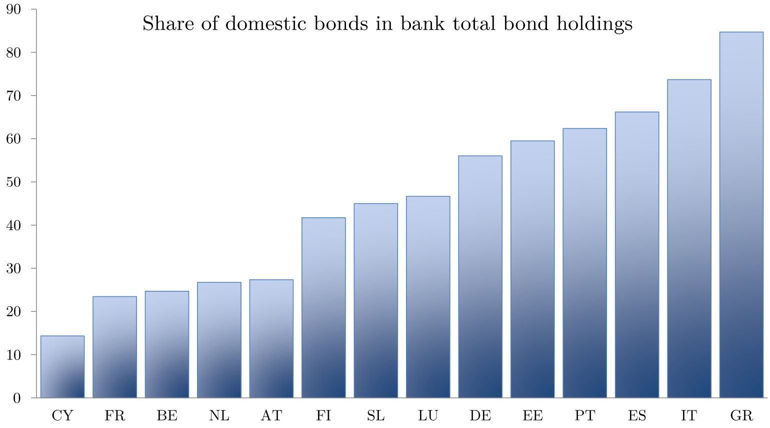
Value-at-Risk

When the probability of default is larger than α banks must:

- Reduce portfolio risk
- Deleverage, thus reducing $\overline{R}$
    - May be required to sell assets if not sufficently capitalized

Back

Home Bias



Source: EU wide Stress Tests 2011

Back

The Model

KPR preferences

King-Plosser-Rebelo utility:

$$u(C_t, L_t) = \frac{\left(C_{t+j} L_{t+j}^{\phi}\right)^{1-\gamma}}{1-\gamma} \tag{1}$$

$$\tag{2}$$

- Compatible with balanced growth
- Scalable risk aversion

The Model

Households

Intratemporal optimality condition

$$\frac{u'_{L,t}}{u'_{C,t}} = \hat{w}_t$$

The Model

Households

Intratemporal optimality condition

$$\frac{u'_{L,t}}{u'_{C,t}} = \hat{w}_t$$

And two intertemporal ones:

$$q_t^D = \beta \mathbb{E}_t \left[\frac{u'_{C,t+1}}{u'_{C,t}} \right]$$

$$q_t^B = \beta \mathbb{E}_t \left[(1 - \Delta_{t+1}) \frac{u'_{C,t+1}}{u'_{C,t}} \right] + \lambda_t^{SS}$$

Back

The Model

Households

Under KPR preferences these become

$$\hat{w}_t = \frac{\phi C_t}{L_t}$$

$$q_t^D = \beta E_t \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\gamma} \left(\frac{L_{t+1}}{L_t} \right)^{\phi(1-\gamma)} \right]$$

$$q_t^B = \beta E_t \left[(1 - \Delta_{t+1}) \left(\frac{C_{t+1}}{C_t} \right)^{-\gamma} \left(\frac{L_{t+1}}{L_t} \right)^{\phi(1-\gamma)} \right] + \lambda_t^{SS}$$

Back

Other constraints

"Skin in the game" constraints
(Holstrom and Tirole 1997, Brunnermeier and Sannikov 2013, He and Krishnamurthy 2013,...)

Other constraints

"Skin in the game" constraints
(Holstrom and Tirole 1997, Brunnermeier and Sannikov 2013, He and Krishnamurthy 2013,...)

- Maximal outside equity is a multiple ω of net worth

Other constraints

"Skin in the game" constraints
(Holstrom and Tirole 1997, Brunnermeier and Sannikov 2013, He and Krishnamurthy 2013,...)

- Maximal outside equity is a multiple ω of net worth
  - ω is state independent

Other constraints

"Skin in the game" constraints
(Holstrom and Tirole 1997, Brunnermeier and Sannikov 2013, He and Krishnamurthy 2013,...)

- Maximal outside equity is a multiple ω of net worth
  - ω is state independent
- Leverage is countercyclical

Other constraints

"Skin in the game" constraints
(Holstrom and Tirole 1997, Brunnermeier and Sannikov 2013, He and Krishnamurthy 2013,...)

- Maximal outside equity is a multiple ω of net worth
  - ω is state independent
- Leverage is countercyclical
- Intermediaries always marginal investor

Other constraints

"Skin in the game" constraints
(Holstrom and Tirole 1997, Brunnermeier and Sannikov 2013, He and Krishnamurthy 2013,...)

- Maximal outside equity is a multiple ω of net worth
  - ω is state independent
- Leverage is countercyclical
- Intermediaries always marginal investor
- No default in equilibrium

Back

Other constraints

Debt Constraints
(Kiyotaki and Moore 1997, Bernanke and Gertler 1989, Gertler and Kiyotaki 2010,...)

- Borrowers must provide collateral to incentivize repayment

Other constraints

Debt Constraints
(Kiyotaki and Moore 1997, Bernanke and Gertler 1989, Gertler and Kiyotaki 2010,...)

- Borrowers must provide collateral to incentivize repayment
  - Constraint depends on asset values but not volatility

Other constraints

Debt Constraints

(Kiyotaki and Moore 1997, Bernanke and Gertler 1989, Gertler and Kiyotaki 2010,...)

- Borrowers must provide collateral to incentivize repayment
  - Constraint depends on asset values but not volatility
- Leverage is countercyclical: shocks reduce net worth more than credit

Other constraints

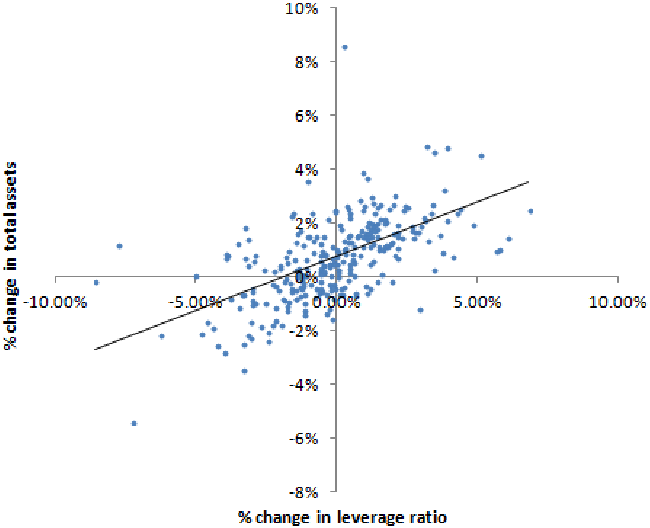
Debt Constraints

(Kiyotaki and Moore 1997, Bernanke and Gertler 1989, Gertler and Kiyotaki 2010,...)

- Borrowers must provide collateral to incentivize repayment
  - Constraint depends on asset values but not volatility
- Leverage is countercyclical: shocks reduce net worth more than credit
- No default in equilibrium

Back

Banks and Leverage



Source: Bank of Spain

Back

Adverse scenario

Adverse scenario: shocks to sovereign credit spreads, by maturity

(in basis points)

Country	3M	1Y	2Y	3Y	5Y	10Y	15Y
Austria	16	16	19	21	23	23	24
France	33	33	38	43	47	48	49
Germany	0	0	0	0	0	0	0
Greece	174	174	201	229	250	255	259
Spain	112	112	130	148	161	164	167
Euro area average	51	51	60	68	74	75	76

Source: ECB.

Source: ECB

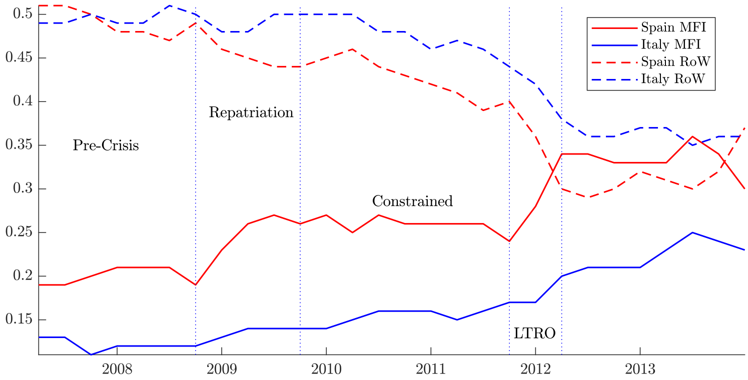
Back

Bond holdings and yields in each stage

Stage	Period	Share of assets			Yields
		MFI	NMFI + HH	ROW	
Pre-crisis	Up to 08Q3	22.63%	16.03%	48.79%	4.2 %
Repatriation	08Q4 to 09Q3	30.07%	13.62%	43.85%	1.9%
Constrained	09Q4 to 11Q3	28.72%	18.84%	40.01%	5.1%
LTRO	11Q4 to 12Q1	39.06%	18.50%	30.32%	2.8%

Back

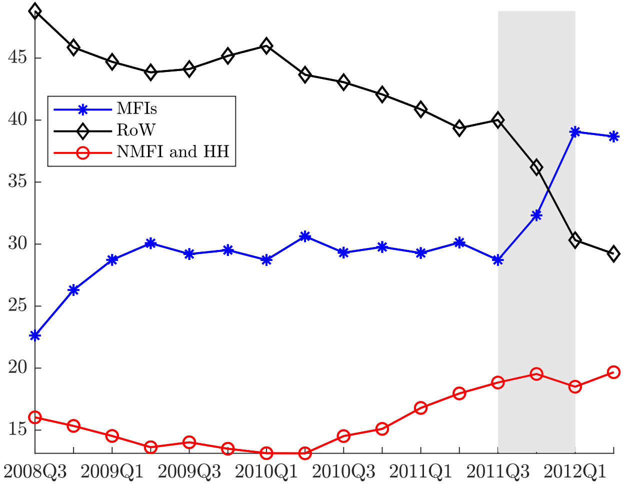
Spanish and Italian bond holdings per sector



Source: Bank of Spain and Bank of Italy

Back

Shares of bond holdings per sector



Source: Bank of Spain

Back

Credit and leverage channels

The credit channel

- Most standard financial constraints do well in describing the direction of credit levels.

Credit and leverage channels

The credit channel

- Most standard financial constraints do well in describing the direction of credit levels.
- Feature procyclical credit levels, but countercyclical leverage

Credit and leverage channels

The credit channel

- Most standard financial constraints do well in describing the direction of credit levels.
- Feature procyclical credit levels, but countercyclical leverage
  - Fall in asset values/net worth makes it harder to borrow, this lowers efficiency of production, leading to a fall in asset values.

Credit and leverage channels

The credit channel

- Most standard financial constraints do well in describing the direction of credit levels.
- Feature procyclical credit levels, but countercyclical leverage
  - Fall in asset values/net worth makes it harder to borrow, this lowers efficiency of production, leading to a fall in asset values.
  - Works even if leverage is fixed

Credit and leverage channels

The credit channel

- Most standard financial constraints do well in describing the direction of credit levels.
- Feature procyclical credit levels, but countercyclical leverage
  - Fall in asset values/net worth makes it harder to borrow, this lowers efficiency of production, leading to a fall in asset values.
  - Works even if leverage is fixed

The leverage channel

- The VaR constraint has procyclical credit and leverage
  - Kalemli-Ozcan et al.(2013), Miranda-Agrippino and Rey (2013)

Credit and leverage channels

The credit channel

- Most standard financial constraints do well in describing the direction of credit levels.
- Feature procyclical credit levels, but countercyclical leverage
  - Fall in asset values/net worth makes it harder to borrow, this lowers efficiency of production, leading to a fall in asset values.
  - Works even if leverage is fixed

The leverage channel

- The VaR constraint has procyclical credit and leverage
  - Kalemli-Ozcan et al.(2013), Miranda-Agrippino and Rey (2013)
- Scope for a leverage amplification channel

Back