Three Essays on Lending, Liquidity and Bank Capital

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Outline

Motivation

Question

What are the determinants of liquidity?
How does it affect price formation?

1. Liquidity: Fundamental characteristic of markets that allow participants to sell positions without incurring in further losses
2. Liquidity as driver of short run market prices (Miller 1977): Equity, pure credit assets, Government Bonds
3. Lending and liquidity: tight relation, to sell an asset first you need to have it or borrow from the holder
4. Lending and Arbitrage capital: Capital restrictions lead to lending restrictions and those to liquidity restrictions

Motivation

Three relevant lending markets:

1. Equity lending market: determines equity liquidity
2. Bank Capital (regulation): determines liquidity of pure credit assets
3. Government Bond market: partially determine liquidity of bank capital

Equity Lending Market

1. Lending is the only way to finance holdings in equity portfolios
2. Big lending patterns could relate to short selling, ¿increases in price efficiency?
3. Market bubbles are less likely to occur in highly liquid markets

Bank Capital

1. Capital restrictions and regulation lead decisions of bank managers, ¿How?
2. Market price of relatively illiquid assets (credit) is highly affected by capital regulation
3. Credit channel is crucial for the transmission of Monetary Policy: Welfare concerns

Bond Liquidity Premiums

1. Government Bond Prices and Bank capital exhibit a cointegration pattern: Higher bank capital higher bond prices, higher bond prices higher bank capital
2. Government Bonds essential assets to provide liquidity to bank balances
3. Liquidity of Government Bonds should affect credit spreads, bank equity valuation and cash markets
4. Contangion accross countries through the Liquidity Channel

Section 1

Stock lending and Market Returns: The Spanish Market

Introduction

Question

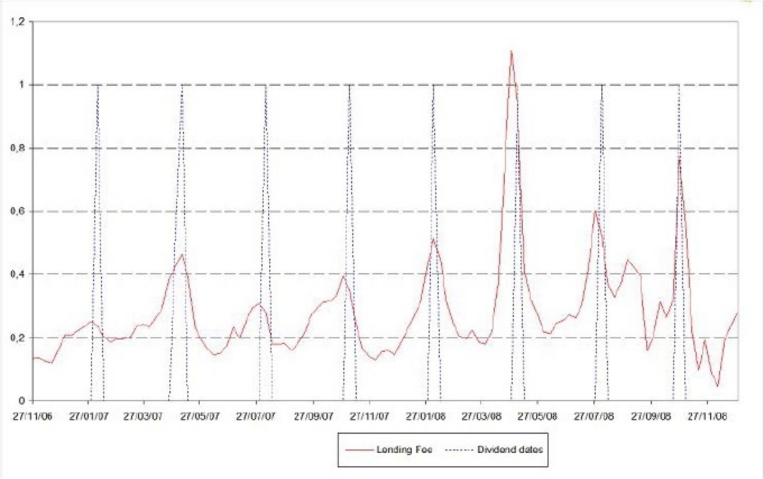
How is equity market liquidity affected by equity lending Market?
Does regulation on Short Selling change that relation?

- First attempt to model the effects of short selling due to Miller [1977]
- Empirical studies (Lamont and Jones [2002], D'Avolio [2002], Bris et al [2007]) have illustrated that short selling activities increase the speed at which information is incorporated into prices, reduce volatility and increase price efficiency (representativity)
- Studies on the effect of equity lending are scarce (Diether et al [2005]): equity lending relates to market liquidity as it is the only way to fund equity positions

Introduction (II)

- Regarding short selling one has to distinguish between two categories:
  - Naked Short Sellling: forbidden in most developed countries (market manipulation)
  - Non-Naked Short Selling: stocks have to be borrowed in advance to be sold in the market. Borrowers pay a convenience yield (Lending fee/rebate rate) to lenders in exchange
- Lending Market is an OTC market
  - Verification of holding at trade dates is hard due to the existence of asynchronies between trading dates and liquidation dates
  - Not all the operations in lending market relate to short selling activities, tax shield on dividend dates and hedge also motivate equity borrowing

Effect of Dividend on Lending Fees



Legal Framework

- Spanish Stock Market is an electronic market:
  - 3 day gap between trading and settlement: Stocks could be borrowed at any moment between this dates, verification of positions lies within custody banks
  - No fail to deliver exists: whenever a counterparty fails to deliver an stock, BME as clearing house issues a Registry Note (market making) to hedge the naked position and charges a penalty to naked entity
- Typical short selling regulation involves limiting operations during this three day gap: 2008 and 2012 short selling bans, stocks have to be borrowed in advance
- Actual owner of stocks are the one effectively holding those, not the lenders. Issues with political rights and dividend rights
- There is no ruling on collaterals for lending purposes. Legal differences between credit operations and lending operations depending on maturity
- Law in recalls is similar to US: lenders have the possibility to recall the position from borrowers at any date

Modelling Approach

- Estimation of supply and demand equations for the lending market making use of two different datasets and the specification in Diether et al [2005]
- Definition of supply and demand shifts making use of the errors of previous estimations
- Construction of a weekly value-weighted index for the whole sample of stocks
- Computation of company specific abnormal returns through CAPM equation
- Construction of bubble indicators as the ratio of market to book values between each date and a reference date

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The Data

- Period: January 2005 to December 2008
- Number of companies: 135 (102)
- Two datasets on lending: Official Records from CNMV and Non-official records of Total Supply for Lending from International Dataexplorers
  - CNMV: Aggregate amount of borrowed stocks
  - International Dataexplorers: Total supply of assets available for lending, lending fees
- Thompson Reuters Dataestream: Trading prices (low, high, open, close), volumes, Balance Sheet data, Right Issuances, Convertibles
- Frequency: Daily$\Longrightarrow$weekly

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Supply and Demand Equations: Shifts

- Following the specification in Diether et al [2005]
    - Supply equation:

$$S_{it} = c_i + \alpha Cost_{it} + \delta Cost_{it} * CNMV_{it} + \sum \beta_j W_{it,-1j} + \sum \delta_j X_{it,j} + u_{it}$$

    - Demand equation:

$$D_{it} = \alpha_i + \beta Cost_{it} + \sum \vartheta_j M_{it-1,j} + \sum \omega_j Z_{it,j} + v_{it}$$

- Those are estimated using a simultaneous equations instrumental variables approach where, $X_{it,j}$, $Z_{it,j}$, $M_{it-1,j}$, $W_{it,-1j}$ are vectors of additional contemporaneous and lagged control variables used as instruments to estimate cost related variables and where the dependent variable is the Lending Interest.
- From errors of those regressions I compute SIN, SOUT, DIN and DOUT using a 1.5 standard deviation threeshold

Estimates of Supply and Demand

Dependent variable: Lend Interest	*I*	*II*	*III*	*IV*
Cost	1.466***	0	-0.123**	0
Past total supply of stocks for lending	0.0002***	0		
Regulatory Note September 22 2008	-1.045***	0.01		
Cost* Regulatory note	-3.740***	0.2979		
Past total supply*Regulatory note	-0.0006***	0.6995		
Lend Interest t-1			0.454***	0
Weeks to dividend			0.135***	0
Market Momentum			-0.497***	0.04
Percentile Lending t-1			-0.005***	0.15
Constant	-0.820***		0.903***	
Observations	16658		16658	
Number of groups	103		103	

*+ significant at 10%; ** significant at 5%; *** significant at 1%*

*Instrumented in Supply Eq.: Cost, Cost*Regulatory Note; Instruments: Lending t-1, Market Momentum, Percentile of Lending t-1, Weeks to Dividend, Lending t-1* Regulatory Note*

*Instrumented in Demand Eq.: Cost; Instruments: Supply t-1, Percentile of Market Capitalization, CNMV*Supply t-1*

Returns and Abnormal Returns

Dependent Variable: Return	*I*	*II*	*III*	*IV*	*V*
Cost	-0.0103***	-0.0103***	-0.0099***	-0.0100***	-0.0101***
Lending interest	-0.0037***	-0.0037***	-0.0034***	-0.0039***	-0.0039***
Dividendo		0.0000	0.0000	-0.0035**	-0.0035**
Direction			0.0057***	0.0053***	0.0053***
Cost x Direction			-0.0009+	0.0000	0.0000
Convertibles				-0.01	-0.01
Rights issuances			0.0155**	0.01	0.01
Cash to Sales				0.0000	0.0000
Leverage				0.0000	0.0000
Lending interest x CNMV					0.0000
Cost x CNMV					0.0000
CNMV					-0.01
Constant	0.0038***	0.0038***	0.0000	0.0000	0.0000
Observations	17043	17043	17043	15111	15111
Number of group	103	103	103	91	91
R-squared	0.31	0.31	0.31	0.31	0.31
*+ significant at 10%; ** significant at 5%; *** significant at 1%*					

Dependent variable: Abnormal Return	*I*	*II*	*III*	*IV*	*V*	*VI*	*VII*
Cost	-0.0082***	-0.0082***	-0.0078***	-0.0078***	-0.0079***	-.0011***	.0003
Cost x Abnormal return>0	0.0176***	0.0176***	0.0175***	0.0174***	0.0174***		
Dividendo		-0.0000	-0.0000	-0.0000	-0.0000	-.0015	-.0025
Direction			0.0042***	0.0041***	0.0041***	.0018***	.0008+
Cost x Direction			-0.0007**	-0.0006**	-0.0006**	-0.0002+	0.0002
Lending interest x Direction			0.0000	0.0000	0.0000		
Convertibles			-0.0000	-0.0000	-0.0000	-.0077+	-.0090+
Rights issuances			0.0076**	0.0064+	0.0064+	-.0050	.0152**
Cash to Sales				0.0000	0.0000	-4.92*10^-6	-9.56*10^-6
Leverage				0.0000	0.0000	1.27*10^-6	-4.67*10^-7
Lending interest x CNMV					0.0000		
Cost x CNMV					0.0000		
CNMV					0.0000	-.0147***	.0202***
Constant	0.0010**	0.0010**	-0.0011+	0.0000	0.0000	-.0152***	.0251***
Observations	17043	17043	17043	15111	15111	7978	7133
Number of group	103	103	103	91	91	91	91
R-squared	0.41	0.41	0.41	0.41	0.41		
*+ significant at 10%; ** significant at 5%; *** significant at 1%*							

Abnormal Return Predictability

Dependent Variable: Abnormal returns t+1	*I*	*II*	*III*	*IV*	*V*	*VI*	*VII*
Cost	-0.0017***	-0.0017***	-0.0017***	-0.0018***	-0.0018***	-0.0016***	-0.0011***
Cost x Abnormal return t >0	0.0001						
DIN		0.0002					
SIN			0.0011**				
SIN & DOUT				0.0014+	0.0014+	0.0014+	0.0013+
Dividendo					-0.0027**	-0.0036**	-0.0038***
Direction						-0.0012+	-0.0012+
Cost x Direction						-0.00003	0.00006
Convertibles						-0.0301***	-0.0291***
Rights issuance						0.0017	0.0010
Cash to Sales						0.00001	0.00001
Leverage						10^-6	2*10^-6
Cost x CNMV							-0.0024***
Constant	0.0011**	0	0	0.0010**	0.0011**	0.0021***	0.0018**
Observations	17246	17246	17246	17246	17246	15043	15043
Number of group	103	103	103	103	103	91	91

*+ significant at 10%; ** significant at 5%; *** significant at 1%*

Stock Lending and the 2008 Market Crash: Short and Long Run Evidence

Dependent Variable: Market to Book	*I*	*II*	*III*	*IV*	*V*	*VI*
Cost	0.0837***	0.0842***	0.0876***	0.0877***	0.0879***	0.0928***
DIN	-0.01					
SIN		0.01				
SIN & DOUT			-0.0569***	-0.0577***	-0.0576***	-0.01
Weeks to dividend				0.0001	0.0001	0.0001
Rights issuance					-0.1842***	-0.2019***
Convertibles					0.2204***	0.2868***
Cash to Sales						-0.0021***
Leverage						-0.00001***
Constant	0.9658***	0.9567***	0.9629***	0.9629***	0.9571***	0.9778***
Observations	17043	17043	17043	17043	17043	15111
Number of group	103	103	103	103	103	91
R-squared	0.02	0.02	0.02	0.02	0.02	0.04
*+ significant at 10%; ** significant at 5%; *** significant at 1%*						

Dependent Variable: Increase in MTB 2008	*I*	*II*	*III*	*IV*	*V*	*VI*
Increase MTB 2007	-0.0833***	-0.0834***	-0.0873***	-0.0845***	-0.0877***	-0.0922***
Cost mean 08	-0.0421***	-0.0416***	-0.0368**	-0.0413***	-0.0367**	-0.0305+
Weeks demand<0		-0.0012			-0.0024	0.0013
Weeks supply<0			-0.005		-0.0032	-0.0004
Weeks supply<0 & demand>0				-0.0028	-0.0034	-0.0017
Rights issuance						-0.01
Convertibles						-0.05
Percentile of lending volume 07						0.0030
Constant	-0.2734***	-0.2428***	-0.1458+	-0.2546***	-0.11	-0.18
Observations	76	76	76	76	76	76
R-squared	0.16	0.16	0.19	0.17	0.19	0.2
*+ significant at 10%; ** significant at 5%; *** significant at 1%*						

Section 2

Welfare Effects of QE under Optimal Bank Capital Structures

Introduction

- Liquidity of credit markets determined by capital regulation $\Longrightarrow$ Capital determines funding costs
- Capital constrained entities follow a deleverage pattern
- Actual crisis started with a banking crisis $\Longrightarrow$ Then transformed into a liquidity problem

Question

How does Basel capital regulation affect assets liquidity?
Is it possible to reduce the adverse effects of capital regulation?

Introduction

- Actual models on bank capital structures (managers decisions) take exogenous assumptions on the liquidity of assets (Estrella [2004], Peura and Keppo [2006], Repullo and Suarez [2013])
- First two references take assumptions on the liquidity of bank equity capital, while the latter assumes perfect illiquidity of equity and perfect liquidity of credit assets paired with a monopolistic environment for borrowers
- Asset liquidity is driven by capital constraints, as illustrated in Kondor [2009] and Acharya and Shin [2013]
- To analyze the liquidity effects of capital regulation and the (welfare) effects of actions aimed to increase that, liqudity has to be endogenized
- Basel III has recognized the effect of liquidity imposing a liquidity ratio to be satisfied by regulated entities

The Set-up

- Discrete time model with two states, $s = \{h, l\}$ and three types of assets:
  - Loans (two period to maturity, subject to capital regulation, managerial costs, c, tradable in the intermediate period at a market price, $P_{s,s'} = 1 - \sigma_{s,s'}$, refinanciable, pay an interest rate r_s)
  - Government bonds (one period to maturity credit assets, managerial costs, c, not subject to capital regulation, no coupon, bought at a price P^u)
  - Bank equity capital (subject to capital regulation, managerial costs, c^e, acquired either by investors or other regulated entities)
- States evolve according to a Markov chain, probability of going to high default probability state is $q_{i,h}$
- Loans and bonds are subject to default risk

The Set-up

- Default distribution: $F_s(x) = \Phi\left(\frac{\sqrt{1-\rho_s}\Phi^{-1}(x)-\Phi^{-1}(p_s)}{\sqrt{\rho_s}}\right)$
- $p_s = E(x|s)$
- $\rho_s = 0.12\left(2 - \frac{1-e^{-50p_s}}{1-e^{-50}}\right)$
- LGD: λ homogeneous for both credit assets
- Regulatory capital (Basel II): $\gamma_s = \frac{\lambda}{2}\Phi\left(\frac{\Phi^{-1}(p_s)+\sqrt{\rho_s}\Phi^{-1}(0.999)}{\sqrt{1-\rho_s}}\right)$

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The Set-up

- Credit assets can only be held by regulated entities (banks)
- Bond supply is exogenous
- There is a unit size continuum of banks
- Bank default rates are heterogeneous
- Banks are financed through equity and deposits. Deposit supply is totally elastic at a deposit rate normalized to zero
- Banks could be recapitalized either by investors (capital injection) or other banks (equity acquisition) if capital to loan ratio is above regulatory level, $k > \gamma_s$, otherwise banks can only recapitalize through deleverage or acquisition of new equity by other banks
- Investors are assumed to hold enough money to recapitalize (intertemporal welfare effects of recapitalization)

Evolution of Bank Capital and Loan Portfolio

- Capital and loan evolution are characterized by the following accountancy identity....

$$K_1^e = \left(r + k + \frac{\Delta n^n \left(\bar{P}_1^e - (1+c^e) \bar{P}^e \right)}{L} - c' + \frac{\chi(1-P)}{1+\chi} - x_1 \left(r + \lambda' \right) \right) L$$

$$L_1^e = (1 - x_1) L \cdot 1_{\{\chi=0\}}$$

...where...

$$\begin{aligned} k &= \frac{K^e + \Delta n^b P_i^e - \xi (1-P) L^e}{L} \\ L &= (1-\xi) L^e \cdot 1_{\{\xi>0\}} + (1+\chi) L^e \cdot 1_{\{\chi>0\}} + max \left(\frac{K^e}{k^*}, L^e \right) 1_{\{\chi=\xi=0\}} \\ L_i^u &= \alpha_i L \\ c' &= c - \alpha_i (1 - c - P_i^u) \\ \lambda' &= (1+\alpha_i) \lambda \end{aligned}$$

The trading decision

Under this set-up, if $P_{s,s'} \geq 1$ the trading decision of banks is:

- Banks holding a capital $1 - P_{s,s'} < k^e < k^{\bar{1}}_{s',s}$ sell loans and use the money to give new loans
- Banks holding a capital $k^{\bar{1}}_{s',s} < k^e$ buy loans until the regulatory constraint is binding
- Loan Price is given by

  $$\int_0^{x^{\bar{k}}_{s'}} \left(K^e_{s'} - \gamma_{s'} L^e_{s'}\right) dF_s(x) = \int_{x^{\bar{k}}_{s'}}^{x^{1-P_{s,s'}}_{s'}} \gamma_{s'} L^e_{s'} dF_s(x)$$

- Bank value is $K^e - (1 - P_{s,s'}) L^e$

- When $P_{s,s'} < 1$ two scenarios may arise....

The trading decision

If $P^{l}_{s'',s} - P_{s'',s} \geq \frac{\left(P^{\bar{e}}_{s,s'} - \bar{P}^{e}_{s}\right)}{\bar{P}^{e}_{s}} - c^{e} \ldots$

- Banks holding a capital $1 - P_{s,s'} < k^{e} < \gamma_{s'}$ are indifferent between selling loans and new equity
- Banks holding a capital $\gamma_{s'} \leq k^{e} \leq k^{\bar{2}}_{s',s}$ either are recapitalized by shareholders or give new loans
- Banks holding a capital $k^{\bar{2}}_{s',s} < k^{e}$ buy loans
- Loan price is given by: $\int_{0}^{x^{\bar{k}}_{s'}} \left(K^{e}_{s'} - \gamma_{s'} L^{e}_{s'}\right) dF_{s}(x) = \gamma_{s} \int_{x^{\gamma_{s'}}_{s'}}^{x^{1-P_{s,s'}}_{s'}} \left(\frac{\left(\gamma_{s'} - k^{e}\right)}{\gamma_{s} - \left(1 - P_{s',s}\right)} L^{e} \right) dF_{s}(x)$
- Bank value is $K^{e} - \left(1 - P_{s,s'}\right) L^{e}$

The trading decision

...Otherwise

- The decision is like in previous case but:
  - Banks holding a capital $k^{\bar{3}}_{s',s} < k^e$ buy equity
  - Bank value is $K^e - (1 - P_{s,s'})\, L^e$
  - Implicit loan value is given by:

$$\int_0^{x^{\bar{k}}_{s'}} \left(K^e_{s'} - \gamma_{s'} L^e_{s'}\right) dF_s(x) = \gamma_{s'} \int_{x^{\gamma_{s'}}_{s'}}^{x^{1-P_{s,s'}}_{s'}} \left(\gamma_{s'} - k^e\right) L^e dF_s(x)$$

General Solution: Implications

- The problem has one state contingent equillibrium $\{r_s^*, k_s^*\}$ when bank managers hold rational, non myopic, expectations
- Prices are unique, depend on previous and current state of the economy and are sufficient statistics of the state of the economy ($P_{s,h} < 1$ and $P_{s,l} > 1$)
- Some existing borrowers suffer refinanciation constraints, some banks hold excess lending capacity
- Interest rates (Spreads) lie within the interval $\left[\left(\frac{1-\beta}{\beta}\gamma_l + c + p_l\lambda\right)\frac{1}{1-p_l}, \left(\frac{1-\beta}{\beta}\gamma_h + c + p_h\lambda\right)\frac{1}{1-p_h}\right]$
- Market value of the Bank value is always equal to residual book value, $K^e - (1 - P_{s',s}) L^e$
- When $k_s^* > \gamma_s$ and $s = h$, there is a mass of banks asking for a capital injection from shareholders
- If $\frac{\left(P^{\bar{e}}_{s,s'} - \bar{P}^e_s\right)}{\bar{P}^e_s} - c^e > P^l_{s'',s} - P_{s'',s}$, capital buffers and spreads are smaller, liquidation losses are bigger
- In recesions, bond prices and capital are positively correlated.

Effect of Parameter Changes: r_s^*

- The effect on equillibrium loan rates, r_s^*, of changing the value of any parameter $\{\lambda, q_{s,h}, \gamma_l, \gamma_h, \delta, c\}$ is...

$a =$	λ	$q_{s,h}$	γ_i	δ	c
$\frac{dV_s}{dP_{s,i}} \frac{dP_{s,i}}{da}$	$(-)$	0	$(-)$	$(-)$	$(-)$
$\frac{dV_s}{da}$	$(-)$	$(-)$	$(-)$	$(-)$	$(-)$
$\frac{dr_s^*}{da}$	$(+)$	$(+)$	$(+)$	$(+)$	$(+)$

Effect of Parameter Changes: k_s^*

...while being not defined for equillibrium capital, k_s^*

$a =$	λ	$q_{s,h}$	γ_i	δ	c
$\frac{\partial^2 V}{\partial k \partial a}$	$(+)$	$(+)$	$(+)$	$(-)$	$(+)$
$\frac{\partial^2 V}{\partial k \partial P}\frac{\partial P}{\partial a}$	$(+)$	0	$(+)$	$(+)$	$(+)$
$\left(\frac{\partial^2 V}{\partial k \partial r} + \frac{\partial^2 V}{\partial k \partial P}\frac{\partial P}{\partial r}\right)\frac{\partial r}{\partial a}$	$(-)$	$(-)$	$(-)$	$(-)$	$(-)$
$\frac{dk_s^*}{da}$	$(?)$	$(?)$	$(?)$	$(?)$	$(?)$

Parameter Values

- For simulation results we use the following values for the parameters...

$a =$	λ	$q_{l,h}$	$q_{h,h}$	δ	c	c^e	p_h	p_l	α_i
	45%	20%	64%	4.85%	3.4%	32%	3.6%	1.1%	10%

Simulation Results: r_s^* and k_s^*

... and benchmark our results against those in Repullo and Suarez [2013]....

	Without Equity Markets	With Equity Markets	RS
r_h^*	1.7%	1.7%	3.3%
r_l^*	0.73%	0.69%	1.3%
k_h^*	6.09%	6.09%	6.70%
k_l^*	6.81%	5.19%	6.90%
$k_h^* - \gamma_h$	60bps	60bps	120bps
$k_l^* - \gamma_l$	365bps	203bps	380bps

Simulation Results: P

...and price predictions

	Model without equity	Model with equity
Loan Prices, $P_{s,s'}$		
State: h after h	93.62%	93.62%
State: l after h	96.05%	96.06%
State: h after l	90.82%	94.07%
State: l after l	95.97%	95.97%
Bond Prices, $P^b_{s'}$		
State: h	95.26%	95.31%
State: l	96.11%	96.17%
Market to book value of capital, $\frac{k^*_{s'}-(1-P_{s,s'})}{k_{s'}}$		
State: h after h	78.98%	78.98%
State: l after h	116.9%	122.2%
State: h after l	17.07%	69.78%
State: l after l	101.46%	101.15%

Welfare Function

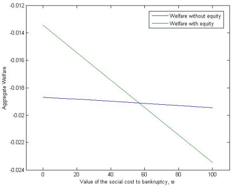
- With this model we can also analyze the welfare effects of market and regulatory actions aimed to increase price liquidity
- Three actions are considered:
  - Short selling regulation
  - Bond purchases
  - Loan purchases
- State contingent welfare is measured with:

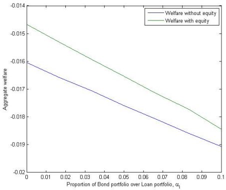
$$W_{s,s'} = \left(NC_{s,s'} - NR_{s,s'} - R_{s,s'}\right)\left(\mu - r^*_{s'}\right) + \omega BR_{s,s'}$$

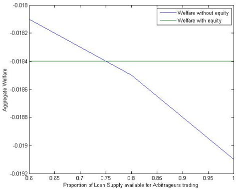
- Then agreggated using ergodic state transition probabilities

QE and Welfare

- The effect of short selling bans (reduction in liquidity) depends on the aversion of the government to assume bank losses: High risk aversion$\Longrightarrow$ Short Selling bans reduce Welfare
- Bond purchases increase Welfare
- Loan purchases have no effect when market liquidity is low. Otherwise the effect is positive







Section 3

Implied Bond Liquidity Premiums

Introduction

- Government Bonds are highly traded “liquid” assets banks tipically use as collateral for their funding operations in the ECB
- Since 2008, the european government bond market has faced turbulences, bond prices reduced
- This leads to a reduction in aggregate bank liquidity (haircuts, downgrades...)

Question

How does government bond liquidity affect other markets?
Is there a liquidity contangion pattern amongst european countries?

Introduction

- Various studies have analyzed the relations between liquidity and credit
  - Empirical: Warga [1992], Fontaine [2012], Ericsson and Renault [2006], Longstaff [2005]
  - Theoretical: Brunnermeier [2008] and Brunnermeier et al [2009]⇒Liqudity and credit quality closely related
  - Acharya and Shin [2013]: Banking Funding constraints in one country lead to illiquidty in other countries (wealth effect)
- Measuring credit liquidity is a difficult task (liquidity non observable)⇒Proxies (Bid-Ask spreads, Traded Volumes...)
- Fontaine [2012]: bond age is relevant to understand US bond liquidity⇒Violation of non-arbitrage condition
  - Why? Plausible explanation: Bond age is a proxy for funding conditions in previous dates
  - Bonds: Held to maturity portfolios⇒Amortizing costs

Affine Model Price Specification

- Christensen et al [2009]: Conditional Nelson Siegel specification⇔Arbitrage Free
- Factors evolve according to Orstein-Uhlenbeck processes, and the price incorporates an additional liquidity factor....

$$\begin{cases} dF = K(\theta - F)dt + \Sigma dB^{Q} \overset{discretization}{\Longrightarrow} F_{i,c,t} - F_{i,c} = k_{i,c}\left(F_{i,c,t} - F_{i,c}\right) + \sigma_{i,c}\epsilon_{i,c,t} \\ P^{*}\left(F_{c,t}, age_{M,c,t}, L_{c,t}\right) = \sum_{m=m_1}^{M} D_{c,t}\left(m\right) \times C_{c,t}\left(m\right) + \zeta_{c}\left(L_{c,t}, age_{M,c,t}\right) + \Omega_{c}\upsilon_{c,t} \end{cases}$$

Affine Model Price Specification

... where

$$\begin{cases} \sum = \begin{pmatrix} \sigma_1 & 0 & 0 & 0 \\ 0 & \sigma_2 & 0 & 0 \\ 0 & 0 & \sigma_3 & 0 \\ 0 & 0 & 0 & \sigma_4 \end{pmatrix} \\ D_{c,t}(m) = e^{-\left(a_{c,t}(m)+\sum_{i=1}^{3} F_{i,c,t}(m)\beta_{i,c,t}\right)m} \\ \beta_{1,c,t} = 1 \\ \beta_{2,c,t} = \frac{(1-e^{-\lambda_1 m})}{\lambda_1 m} \\ \beta_{3,c,t} = \frac{(1-e^{-\lambda_1 m})}{\lambda_1 m} - e^{-\lambda_1 m} \\ \zeta_c\left(L_{c,t}, age_{M,c,t}\right) = L_{c,t} e^{\left(-\frac{1}{\kappa} age_{M,c,t}\right)} \end{cases}$$

The Data

- 12 European Countries data (5 Core Countries + 5 Non-core countries + Deutschland + Switzerland) :
    - Bond Prices
    - Coupon
    - Time to Maturity
    - Age
    - CDS spreads
    - Repo rates
- Market-to-Book Value of Eurostoxx 600 Banking Index
- IRS rates
- Euribor Rates
- Weekly Frequency
- January 2007 to December 2011 $\Longrightarrow$ Abstracting from Central Bank Actions

Estimation Methodology

- Non-Linear State-Space representation⇒Unscented Kalman Filter

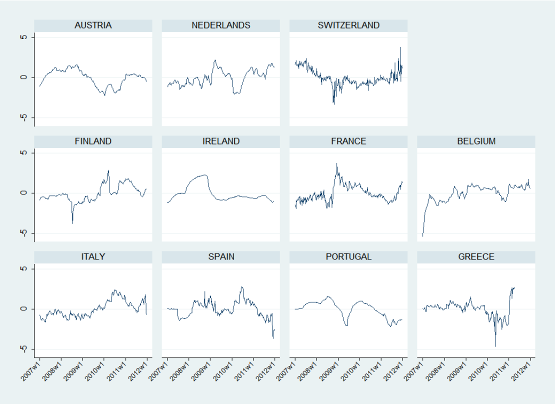
$$\begin{cases} F_{c,t} - F_c = K_c \left(F_{c,t} - F_c \right) + \Sigma \epsilon_{c,t} \\ P_t = \phi \left(F_{c,t}, C_{c,t}, age_{c,t} \right) + \Omega \theta_t \end{cases}$$

- Price volatility:Ωdiagonal matrix
- Individual Price volatility$\Omega_i = \omega_0 + \omega_1 m > 0$
- Likelihood function: $L(\omega) = \sum_{t=1}^{T} l(P_t; \omega) = \sum_{t=1}^{T} log \left(\Phi \left(P_{t+1,t}, \Omega_{t+1,t}; \omega \right) \right)$
- Parameter restrictions: $\lambda_1, \kappa > 0,\ k_i \epsilon [-1, 1],\ D_{c,t}(m) \leq 1$
- Country level estimation
- Multiple Starting Points
- Spillover Liquidity effects accross countries⟹ Predictive regressions
- Predictability of excess returns
- Effect of liquidity in other markets⟹ Predictive regressions

Liquidity Factor

- Liquidity factor relevant for all countries but Deutschland
- Decay parameter estimates: Low values for Spain, Italy, Portugal and Greece (on average 0.69) for the others 2.54
- Average liquidity factor:
  - Very negative for France and Belgium⟹Banking sector highly damaged
  - Low effect for Core countries⟹0.29 $ lower price in new issuances
  - Higher effect for Non-Core countries⟹0.83 $ lower price in new issuances

Evolution of Liquidity



Spillover effects

	AT	NL	FI	FR	BE	IE	ES	GR	IT	PT
L.AT	0.990***	0.0220***	-0.0256***	-0.0530***		-0.0128***	-0.0862***	0.172***		-0.0317***
	(0.000)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)		(0.000)
L.FI	0.0387***	-0.0280***	0.931***		0.0193***	0.00666***	0.0141**	0.0858***	0.00807**	-0.0200***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.014)	(0.000)	(0.012)	(0.000)
L.FR	-0.0300***	0.0283***	0.0103***	0.887***		-0.0386***	0.0280***	-0.0394***	-0.0168***	-0.0172***
	(0.000)	(0.000)	(0.002)	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L.BE	-0.0141***	-0.0463***	-0.0237***	0.0439***	0.916***	0.00573***	-0.00714**	0.0839***	0.0472***	0.00670***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.010)	(0.019)	(0.000)	(0.000)	(0.004)
L.IE	0.00396		-0.0204***	0.0315***	-0.0229***	0.994***	0.156***	-0.115***	-0.0436***	
	(0.358)		(0.000)	(0.010)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	
L.ES	0.0142***	0.0489***	-0.0178***		0.0401***	-0.0224***	0.882***	0.0693***	0.0241***	-0.0236***
	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L.GR	-0.0171***	0.0362***		-0.0511***		0.00169	-0.0479***	0.788***	-0.0358***	
	(0.000)	(0.000)		(0.000)		(0.107)	(0.000)	(0.000)	(0.000)	
L.IT	-0.0356***	0.0548***	0.0390***	-0.0871***	-0.0426***	-0.00617***		-0.129***	0.921***	-0.00926***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.009)		(0.000)	(0.000)	(0.007)
L.PT	-0.00770**	-0.0357***	0.0287***		-0.0262***	0.0146***	-0.132***		0.0212***	1.006***
	(0.029)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)		(0.005)	(0.000)
L.NL		0.965***	0.0263***	0.0297***	0.0196***		-0.0896***		-0.0124**	
		(0.000)	(0.000)	(0.000)	(0.000)		(0.000)		(0.011)	
Observations	2441	2441	2811	2441	2811	2441	2441	2431	2441	2811

p-values in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Spillover effects: Conclusions

- Robust (sign) independently of the number of prediction lags
- Suggest the following categorization:

	Big Market	Small Market
Core countries	France, Belgium	Austria, Nederlands, Finland
Non-Core countries	Spain, Italy	Greece, Portugal, Ireland

  - Spain leads Italy; Belgium leads France
  - Liquidity increases in big countries leads to liquidity reductions in smaller markets (the opposite is also true)$\Longrightarrow$Flight to liquidity
  - Liquidity increases in big core countries leads to liquidity increases in non core countries$\Longrightarrow$Wealth effect

Liquidity and Bond Market Excess Returns

	1Y YIELD	2Y YIELD	3Y YIELD	4Y YIELD	5Y YIELD	7Y YIELD	10Y YIELD
3 Months	-0.546***	-0.571***	-0.574***	-0.561***	-0.535***	-0.467***	-0.401***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.003)
6 Months	-0.556***	-0.557***	-0.547***	-0.526***	-0.498***	-0.431**	-0.343**
	(0.007)	(0.005)	(0.006)	(0.007)	(0.009)	(0.016)	(0.036)
12 Months	-0.336*	-0.306	-0.276	-0.247	-0.219	-0.164	-0.0887
	(0.078)	(0.100)	(0.128)	(0.162)	(0.202)	(0.301)	(0.521)
R^2 3 Months	0.285 (0.223)	0.308 (0.246)	0.313 (0.254)	0.312 (0.258)	0.310 (0.260)	0.302 (0.260)	0.286 (0.253)
$R^2$6 Months	0.250 (0.188)	0.263 (0.205)	0.265 (0.213)	0.266 (0.219)	0.267 (0.224)	0.267 (0.232)	0.258 (0.233)
R^2 12 Months	0.134 (0.115)	0.149 (0.134)	0.160 (0.148)	0.172 (0.162)	0.186 (0.178)	0.217 (0.212)	0.248 (0.247)

p-values in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Liquidity, Repo Market Excess Returns and the CDS market

	3 Months	6 Months	9 Months	12 Months	24 Months
LIQUIDITY	-0.0991*	-0.126**	-0.155**	-0.172**	-0.209*
	(0.078)	(0.042)	(0.025)	(0.020)	(0.064)

	3 Months	6 Months	9 Months	12 Months
LIQUIDITY	-0.433***	-0.385**	-0.284*	-0.211
	(0.009)	(0.028)	(0.095)	(0.215)
LEVEL	0.733***	0.835***	0.845***	0.683**
	(0.000)	(0.000)	(0.002)	(0.026)
SLOPE	0.381**	0.130	-0.0263	-0.181
	(0.021)	(0.382)	(0.850)	(0.230)
CURVATURE	-0.472**	-0.413**	-0.106	0.287**
	(0.015)	(0.029)	(0.452)	(0.039)
R^2	0.304 (0.252)	0.271 (0.233)	0.174 (0.154)	0.111 (0.098)

p-values in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Liquidity and Bank Capital

	3 Months	6 Months	9 Months	12 Months
BELGIUM	-0.150***	-0.158***	-0.169***	-0.125***
	(0.002)	(0.001)	(0.000)	(0.000)
FRANCE	-0.183***	-0.109***		
	(0.000)	(0.003)		
IRELAND	-0.255***	-0.256***	-0.206***	-0.148**
	(0.000)	(0.000)	(0.000)	(0.033)
ITALY	-0.298***	-0.283***	-0.235***	-0.193***
	(0.000)	(0.000)	(0.000)	(0.000)
PORTUGAL	0.241***	0.167***		
	(0.000)	(0.004)		
α	1.277***	1.216***	1.101***	1.084***
	(0.000)	(0.000)	(0.000)	(0.000)
R^2	0.845	0.827	0.811	0.721

p-values in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Liquidity and the Interbank Cash Market

	2007-2011	2007	2007-2008	2007-2009	2007-2010
AUSTRIA	0.0691**		0.175***	0.0775*	0.115***
	(0.010)		(0.006)	(0.098)	(0.008)
IRELAND	0.117***	-0.696***	0.164***	0.209***	0.110***
	(0.002)	(0.000)	(0.001)	(0.000)	(0.006)
BELGIUM		0.0730***			
		(0.002)			
SPAIN		0.205**			
		(0.038)			
NEDERLANDS		0.418***	-0.276***	-0.118***	
		(0.000)	(0.001)	(0.008)	
PORTUGAL		1.992***		-0.188***	
		(0.000)		(0.000)	
GREECE				0.198***	
				(0.006)	
ITALY				0.244***	0.0678**
				(0.000)	(0.043)
Adjusted R^2	0.381	0.826	0.578	0.506	0.500

p-values in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

THANKS FOR YOUR ATTENTION