Collateral Supply and Interactions with Unsecured Lending

(Preliminary results)

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Motivation

Money markets are the veins of the economy

- Money markets allow liquidity allocations:
  - Money markets allow investors to efficiently exploit their liquidity surpluses through lending.
  - This represents an important channel of funding to their counterparts.
    - **Hence, money markets allow developments of investment opportunities and projects in the economy!!!**

Motivation

Two relevant segments that have been commonly investigated

Unsecured money market vs. **Collateralized money market**

"Where I come from it's called collateral."

Uncollateralized lending

Lending is protected through the use of collateral.

Motivation

First contribution of our paper

- Collateralized money market has become much more important after the last crisis (see, e.g. Mancini et al., 2016 RFS).

- Investors fear about an evaporation of collateral.

- In the event of a panic all of their borrowed collateral will be withdrawn and they'll have to start liquidating many positions.

  – This a potential source of systemic risk

- This echoes to an earlier literature in relation to the concept of "Flight to Collateral"
  – Fostel and Geanakoplos (2008, AER) argue that during periods of stress, asset prices generally fall, but "collateral values" often rise, and so assets with higher collateral values fall less.

- **Thus, our first contribution is to provide a tool, which can capture from market data the evolution of the collateral supply in money markets.**

Motivation

Second contribution of our paper

- The majority of the existing literature focuses its analysis independently either on the unsecured segment or on collateralized lending:

  - Unsecured money market (UM)
    - E.g., Furfine (2002, EER), Afonso et al. (2011, JF), Brunnetti, Di Filippo and Harris (2011, RFS) and Acharya and Merrouche (2013, RoF).

  - Collateralized money market (CM)
    - E.g., Fostel and Geanakoplos (2008, AER), Gorton and Metrick (2010a,b), Gorton and Metrick (2012a,b), Krishnamurthy et al. (2013), Copeland et al. (2013), Boissel et al. (2014) and Gorton and Ordonez (2014, AER).

- There are no many studies in which UM and CM have been simultaneously studied.

  - **The second contribution of our paper is to fill this gap. We argue about the necessity of incorporating the unsecured lending to understand the collateral supply at the repo market.**

Research Aims: The big picture of our study

Objective:

- We analyze the evolution of collateral supply in money markets.

How?

- We introduce a structural model that captures, from market data, the evolution of the collateral supply in money markets.
- The evolution of the collateral supply is obtained taking into account the interaction in unsecured and collateralized lending segments.
  - We use a unique dataset of money markets in Mexico between January 2, 2007 and June 28, 2013.

Why?

- The study of the collateral supply in money markets is crucial, since a lack of supply can be a potential source of systemic risk.
- There are no studies about the information contained in the interplay between unsecured and collateralized segments.
  - Money market interactions can provide useful information to characterize economic variables and to evaluate policy measures.

The model

The basic setup

- We consider a multi-period model
  - Activity over I trading days, with: $i = 1,\ldots,I$
  - Time evolving continuously within each trading day and represented by $t \in [0,T]$

- Two goods: Numeraire (Dollars) and Land .
  - Dollars: reproducible and productive
  - Land: Non-reproducible and it cannot be used as investment to generate more land.

- There is a continuum of two types of firms (i.e. banks): Lenders, L, and borrowers, B.
  - Banks are risk neutral.

The model

Endowments and investment opportunities

- Banks differ in their initial endowments and investment opportunities.
  - A bank type L at any period *i*:
    - M_i dollars, which is random:
      - $M_i \sim \text{Poisson}(\xi)$
    - No investment opportunity
    - No Land
  - A bank type B at any period *i*:
    - Investment opportunity
      - It delivers a return R
      - It can be invested Q_i (which is very big: $M_i \leq Q_i$)
    - Zero dollars
    - Land: $X_{CM,i}$ which can be used as collateral to obtain funding resources.
      - But, only CM_i can be obtained with this type of collateral in the money market ($CM_i \leq X_{CM,i}$)
        - » CM_i is random: $CM_i \sim \text{Poisson}(\xi_{CM})$
        - » Where h is the haircut, with $h = CM_i / X_{CM,i}$.
        - » This also reflects the implicit cost of obtaining a good collateral
          - » Good collateral is scarce and costly
- Hence, resources are in the wrong hands:
  - **Financial intermediation emerges!**

The model

The money market

- Unsecured money market (UM).
  - A bank B can borrow at period i an amount of dollars UM_i from a bank L (for one period)
  - Interest rate r_{UM}
  - Collateral = zero land

- Collateralized money market (CM).
  - A bank B can borrow at period i an amount of dollars CM_i from bank L (for one period)
  - Interest rate r_{CM}, where $r_{CM} \leq r_{UM} \leq R$
  - Collateral= $X_{CM,i}$ of land
    - But, only CM_i ~ Poisson(ξ_{CM}) can be obtained with this type of collateral in the money market

- Therefore, a bank B will borrow dollars from a bank type L:
  - CM_i from the collateralized money market
  - UM_i from the unsecured money market
    - Where $CM_i + UM_i = M_i$
    - Hence, UM_i also follows a Poisson process (from Raikov's theorem since M_i ~ Poisson(ξ))
    - Let assume that UM_i ~ Poisson(ξ_{UM})

The model

The economy has three states in term of average supply of land (collateral)

- As a first step lets assume (for few slides) that the funding supply is constant
  - The endowment of M dollars of a bank L is constant (i.e. $M_i = M$).

- Suppose that the average supply of land (ξ_{CM}) can present: an increase, a decrease, or to keep unmodified:
  - This can induce changes in opposite directions in the market activity in the collateralized and unsecured money markets.

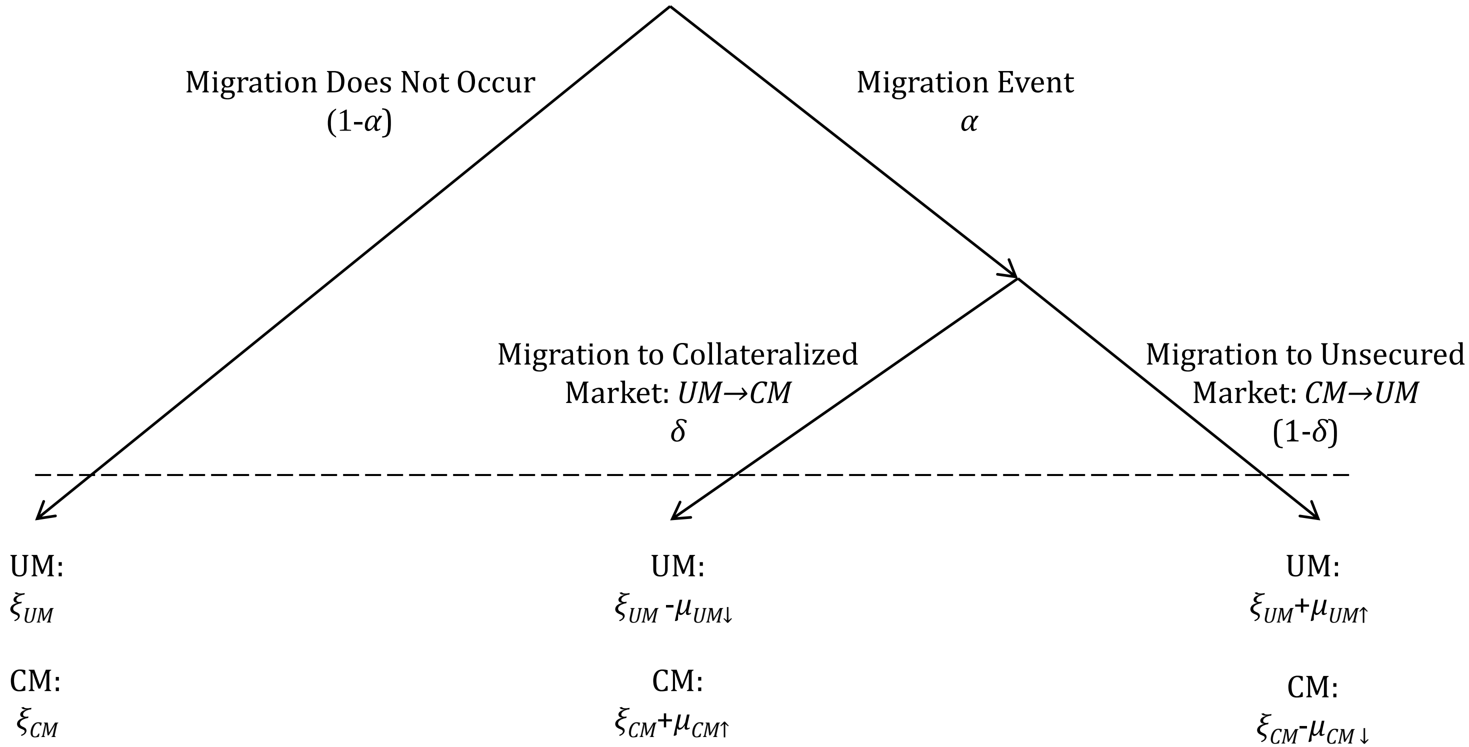
  - If we assume that the amount to be invested , $CM_i + UM_i = M$, is constant:
    - When CM↑ ⇒ UM↓
    - When CM↓ ⇒ UM↑

    $\Big\}$ Migration event

- A migration event due to a change in the supply of land takes place on each day, and with probability $\alpha \in (0,1)$:
  - UM → CM with probability δ:
    - » The average activity in UM is reduced by $\mu_{UM\downarrow}$
    - » The average activity in CM increases by $\mu_{CM\uparrow}$
  - CM → UM with probability (1-δ)
    - » Activity in UM increases by $\mu_{UM\uparrow}$
    - » Activity in CM is reduced by $\mu_{CM\downarrow}$

The Model

Tree diagram of the dynamics in the money market model



A branch of the tree can happen once per day below the dashed line

With:

$$\xi_{UM} > \mu_{UM\downarrow} > 0$$

$$\xi_{CM} > \mu_{CM\downarrow} > 0$$

The model

Interest rates

$$r_i^{CM} \equiv (r_{NoMig,i}^{CM}, r_{UM\rightarrow CM,i}^{CM}, r_{CM\rightarrow UM,i}^{CM})$$

$$r_i^{UM} \equiv (r_{NoMig,i}^{UM}, r_{UM\rightarrow CM,i}^{UM}, r_{CM\rightarrow UM,i}^{UM})$$

- r_i^{CM} and r_i^{UM} are the vectors of random variables that represent the interest rates in CM and UM on day i, respectively, conditional on:
  - No migration between money markets
  - Migration from UM to CM
  - Migration from CM to UM

- Rates are fundamental values, in each state, that reflect the costs associated to lend in each money market:
  - r_i^{CM} incorporates a premium
    - Average cost associated to lend in CM in each state (i.e. liquidation costs, research of collateral quality)
    - e.g. a linear rate premium given by $k_{CM}\, CM_i$
  - r_i^{UM} incorporates a premium
    - Average cost associated to lend in UM in each state (i.e. default costs)
    - e.g. a linear rate premium given by $k_{UM}\, UM_i$

The model

Information setup

- On each date i, agents do not know in which state of the economy they are.
  - In each state of the economy, there are 3 random processes
    - *No Migration:* $CM_i \sim \text{Poisson}(\xi_{CM})$
    - $UM \rightarrow CM : CM_i \sim \text{Poisson}(\xi_{CM} + \mu_{CM\uparrow})$
    - $CM \rightarrow UM : CM_i \sim \text{Poisson}(\xi_{CM} - \mu_{CM\downarrow})$

- Therefore, on each date i, agents cannot identify clearly which state is present.

- However, agents continuously learn and update their beliefs from the lending requirements that they observe on each date:

    - They follow an optimal Bayesian scheme.

The model

Information setup

- Suppose that agents' prior beliefs on each day *i* are represented by the vector:

$$P_i \equiv (P_i(NoMig), P_i(UM \to CM), P_i(CM \to UM))$$

- In case of borrowing requirements in CM and UM on date i (CM_i and UM_i, respectively), the agents will update their beliefs using a Bayesian rule, by which her posterior probability of no migration between money markets is:

$$P_i(NoMig|(UM_i, CM_i)) = \frac{P_i((UM_i, CM_i)|NoMig)P_i(NoMig)}{P_i((UM_i, CM_i))}$$

- Their posterior probability of a migration from UM to CM is:

$$P_i(UM \to CM|(UM_i, CM_i)) = \frac{P_i((UM_i, CM_i)|NoMig)P_i(UM \to CM)}{P_i((UM_i, CM_i))}$$

- Their posterior probability of a migration from CM to UM is:

$$P_i(CM \to UM|(UM_i, CM_i)) = \frac{P_i((UM_i, CM_i)|CM \to UM, \hat{\varphi})P_i(CM \to UM)}{P_i((UM_i, CM_i))}$$

The model

Information setup

- Thus, the interest rate in CM on date i, conditional on the borrowing requirement CM_i and UM_i is:

$$r_i^{CM} = P_i(NoMig|(UM_i, CM_i))r_{NoMig,i}^{CM} + P_i(UM \to CM|(UM_i, CM_i))r_{UM \to CM,i}^{CM}$$

$$+ P_i(CM \to UM|(UM_i, CM_i))r_{CM \to UM,i}^{CM}$$

- A similar expression can be obtained for the interest rate in UM on date i conditional on the borrowing requirement UM_i:

$$r_i^{UM} = P_i(NoMig|(UM_i, CM_i))r_{NoMig,i}^{UM} + P_i(UM \to CM|(UM_i, CM_i))r_{UM \to CM,i}^{UM}$$

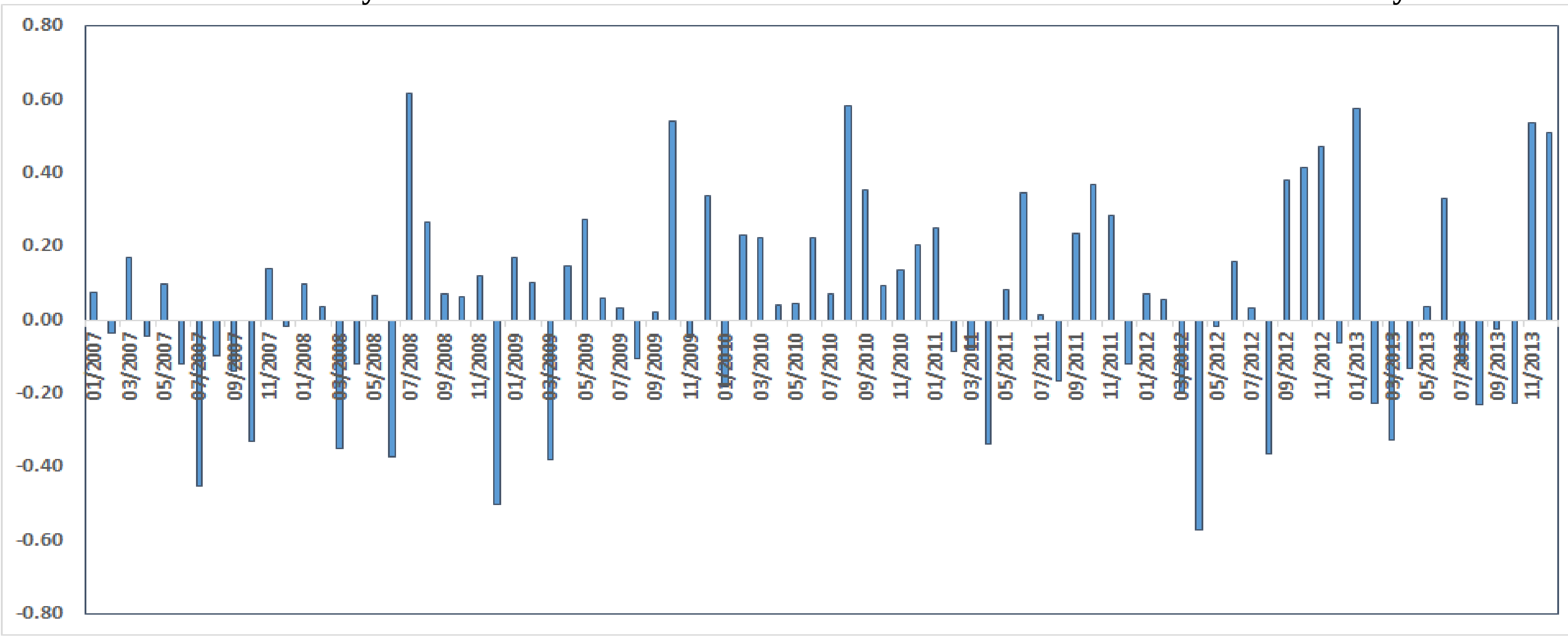
$$+ P_i(CM \to UM|(UM_i, CM_i))r_{CM \to UM,i}^{UM}$$

- **Therefore, agents' beliefs regarding to the supply of land (collateral) can affect interest rates in both money markets.**

The model

- Question from the audience:
  - Alejandro, your model is too constrained, you are assuming that money markets are only moving in opposite direction
  - This is not true, since in some periods lending activity can simultaneously move in both markets in the same direction.
    - E.g. when the funding provision change over time

Monthly correlations between the volume in UM and CM for the Mexican money market



- **Can you take into account this fact from the data?**
  - **Answer: of course it is important to consider these events!!!**

The model

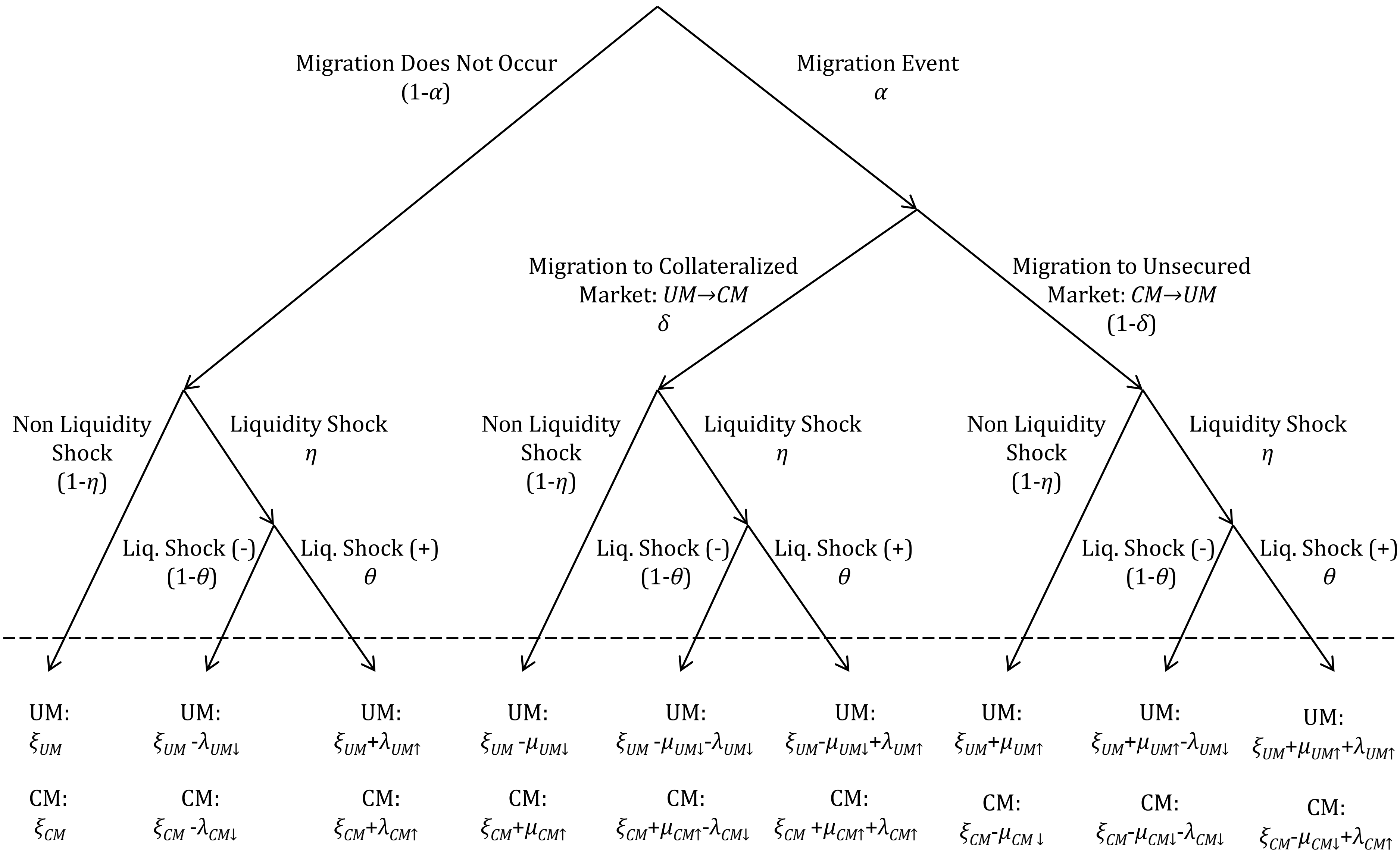
Additional dynamics in money market

- We include changes <u>in the same direction</u> in the market activity in the collateralized and unsecured money markets

  – A liquidity shock (same-sign variation in trading) takes place on each day and with probability $\eta \in (0,1)$:
    - » Positive liquidity shock (UM↑ & CM↑) with probability θ:
      - » Activity in UM increases by $\lambda_{UM\uparrow}$
      - » Activity in CM increases by $\lambda_{CM\uparrow}$
    - » Negative liquidity shock (UM↓ & CM↓) with probability (1-θ):
      - » Activity in UM is reduced by $\lambda_{UM\downarrow}$
      - » Activity in CM is reduced by $\lambda_{CM\downarrow}$

The Model

Tree diagram of the dynamics in the money market model



A branch of the tree can happen once per day below the dashed line

The model

- The likelihood function per a day i:

$$
\begin{aligned}
&L(\varphi|UM_i,CM_i)\\
&=\alpha(1-\delta)\eta\theta\left\{e^{-(\xi_{UM}+\mu_{UM\uparrow}+\lambda_{UM\uparrow})}\frac{(\xi_{UM}+\mu_{UM\uparrow}+\lambda_{UM\uparrow})^{UM_i}}{UM_i!}e^{-(\xi_{CM}-\mu_{CM\downarrow}+\lambda_{CM\uparrow})}\frac{(\xi_{CM}-\mu_{CM\downarrow}+\lambda_{CM\uparrow})^{CM_i}}{CM_i!}\right\}\\
&+\alpha(1-\delta)\eta(1-\theta)\left\{e^{-(\xi_{UM}+\mu_{UM\uparrow}-\lambda_{UM\downarrow})}\frac{(\xi_{UM}+\mu_{UM\uparrow}-\lambda_{UM\downarrow})^{UM_i}}{UM_i!}e^{-(\xi_{CM}-\mu_{CM\downarrow}-\lambda_{CM\downarrow})}\frac{(\xi_{CM}-\mu_{CM\downarrow}-\lambda_{CM\downarrow})^{CM_i}}{CM_i!}\right\}\\
&+\alpha(1-\delta)(1-\eta)\left\{e^{-(\xi_{UM}+\mu_{UM\uparrow})}\frac{(\xi_{UM}+\mu_{UM\uparrow})^{UM_i}}{UM_i!}e^{-(\xi_{CM}-\mu_{CM\downarrow})}\frac{(\xi_{CM}-\mu_{CM\downarrow})^{CM_i}}{CM_i!}\right\}\\
&+\alpha\delta\eta\theta\left\{e^{-(\xi_{UM}-\mu_{UM\downarrow}+\lambda_{UM\uparrow})}\frac{(\xi_{UM}-\mu_{UM\downarrow}+\lambda_{UM\uparrow})^{UM_i}}{UM_i!}e^{-(\xi_{CM}+\mu_{CM\uparrow}+\lambda_{CM\uparrow})^{CM})}\frac{(\xi_{CM}+\mu_{CM\uparrow}+\lambda_{CM\uparrow})^{CM_i}}{CM_i!}\right\}\\
&+\alpha\delta\eta(1-\theta)\left\{e^{-(\xi_{UM}-\mu_{UM\downarrow}-\lambda_{UM\downarrow})}\frac{(\xi_{UM}-\mu_{UM\downarrow}-\lambda_{UM\downarrow})^{UM_i}}{UM_i!}e^{-(\xi_{CM}+\mu_{CM\uparrow}-\lambda_{CM\downarrow})}\frac{(\xi_{CM}+\mu_{CM\uparrow}-\lambda_{CM\downarrow})^{CM_i}}{CM_i!}\right\}\\
&+\alpha\delta(1-\eta)\left\{e^{-(\xi_{UM}-\mu_{UM\downarrow})}\frac{(\xi_{UM}-\mu_{UM\downarrow})^{UM_i}}{UM_i!}e^{-(\xi_{CM}+\mu_{CM\uparrow})}\frac{(\xi_{CM}+\mu_{CM\uparrow})^{CM_i}}{CM_i!}\right\}\\
&+(1-\alpha)\eta\theta\left\{e^{-(\xi_{UM}+\lambda_{UM\uparrow})}\frac{(\xi_{UM}+\lambda_{UM\uparrow})^{UM_i}}{UM_i!}e^{-(\xi_{CM}+\lambda_{CM\uparrow})}\frac{(\xi_{CM}+\lambda_{CM\uparrow})^{CM_i}}{CM_i!}\right\}\\
&+(1-\alpha)\eta(1-\theta)\left\{e^{-(\xi_{UM}-\lambda_{UM\downarrow})}\frac{(\xi_{UM}-\lambda_{UM\downarrow})^{UM_i}}{UM_i!}e^{-(\xi_{CM}-\lambda_{CM\downarrow})}\frac{(\xi_{CM}-\lambda_{CM\downarrow})^{CM_i}}{CM_i!}\right\}\\
&+(1-\alpha)(1-\eta)\left\{e^{-(\xi_{UM})}\frac{(\xi_{UM})^{UM_i}}{UM_i!}e^{-(\xi_{CM})}\frac{(\xi_{CM})^{CM_i}}{CM_i!}\right\}
\end{aligned}
$$

- Across the I days the total likelihood function is:

$$L(\varphi|\mathcal{M})=\prod_{i=1}^{I}L(\varphi|UM_i,CM_i)$$

The data

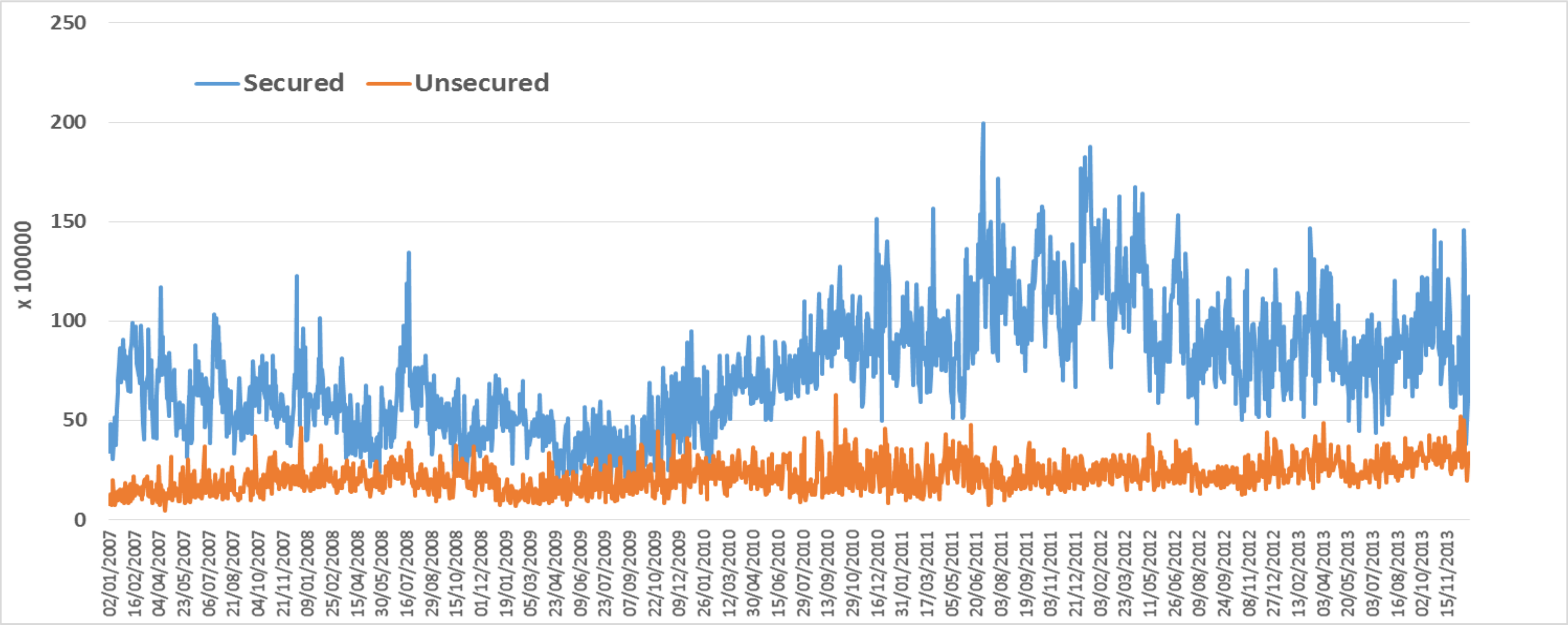
- We use a unique dataset of money markets in Mexico between January 2, 2007 and June 28, 2013.

- Commercial Banks, among other financial institutions, are required by law to report to the Central Bank all daily activity.
  - We observe all their transactions at the unsecured and collateralized money markets
  - For both markets, and per transaction, we observe: counterparties, volume, interest rate, loan maturity.
  - For the collateralized market, and per transaction, we also observe: haircut, number of assets used as collateral, collateral maturity, other collateral characteristics.

- To reduce the level of noise we aggregate data on daily basis

The data

Volume of Unsecured and Collateralized MMs (US Dollars)



Results

Estimated parameters of the structural model (estimated in each semester)

(Standard errors are calculated through bootstrapping and reported in parentheses)

	α	δ	η	θ	ξ_{UM}	ξ_{CM}	$\mu_{UM\downarrow}$	$\mu_{CM\uparrow}$	$\mu_{UM\uparrow}$	$\mu_{CM\downarrow}$	$\lambda_{UM\downarrow}$	$\lambda_{CM\downarrow}$	$\lambda_{UM\uparrow}$	$\lambda_{CM\uparrow}$
1° 2007	0.54	0.66	0.62	0.91	1,222,824.22	4,250,791.72	0.06	1,578,690.76	957,895.58	8,508.83	1,222,824.09	1,230,034.43	69,561.55	2,741,662.22
	(0.09)	(0.12)	(0.11)	(0.10)	(4.50)	(17.44)	(2.88)	(18.78)	(10.35)	(19.71)	(3.57)	(22.87)	(6.11)	(17.77)
1° 2008	0.54	0.53	0.62	0.28	1,917,244.17	4,895,479.60	18.50	2,401,680.18	966,963.55	19.47	22.43	1,286,949.69	568,684.99	1,497,511.83
	(0.12)	(0.21)	(0.12)	(0.22)	(7.39)	(18.67)	(4.20)	(22.98)	(9.94)	(20.61)	(6.51)	(9.72)	(13.96)	(20.23)
1° 2009	0.55	0.59	0.58	0.64	1,464,914.13	3,689,737.27	410,936.19	1,423,781.89	832,924.48	5.64	108,266.51	1,085,850.78	223,337.41	1,334,839.01
	(0.07)	(0.10)	(0.09)	(0.17)	(8.24)	(22.33)	(6.24)	(18.52)	(15.01)	(29.01)	(9.10)	(17.43)	(14.12)	(24.30)
1° 2010	0.66	0.74	0.53	0.69	2,472,835.31	5,510,739.08	279,660.28	1,533,165.05	169,385.20	1,957,343.01	499,059.58	1,041,158.89	637,154.85	1,272,442.15
	(0.09)	(0.09)	(0.07)	(0.20)	(7.03)	(18.35)	(6.75)	(14.52)	(7.02)	(16.51)	(6.15)	(20.80)	(5.61)	(12.12)
1° 2011	0.38	0.43	0.59	0.11	3,023,840.33	8,962,217.62	549,476.47	2,330,603.95	668,083.45	2,354,734.98	1,181,486.51	607,579.61	848,291.71	4,089,731.35
	(0.11)	(0.14)	(0.08)	(0.12)	(8.75)	(6.91)	(5.23)	(10.96)	(6.65)	(16.51)	(9.53)	(18.83)	(7.56)	(27.77)
1° 2012	0.54	0.32	0.66	0.7	3,007,699.82	10,797,646.62	173,712.86	2,743,097.48	484,769.16	2,559,483.89	404,625.94	1,491,318.48	39.09	3,237,213.64
	(0.10)	(0.24)	(0.12)	(0.19)	(3.77)	(14.07)	(3.31)	(14.53)	(204.02)	(13.48)	(4.22)	(14.83)	(3.47)	(15.92)
1° 2013	0.37	0.66	0.51	0.22	3,393,841.03	8,411,943.52	290,553.41	2,389,003.89	906,540.08	1,408,999.78	460,099.49	2,055,523.14	862,075.60	1,413,854.09
	(0.16)	(0.18)	(0.09)	(0.22)	(9.23)	(16.98)	(7.36)	(24.07)	(21.06)	(18.81)	(5.69)	(10.65)	(8.40)	(18.36)

- The model is estimated by maximizing the likelihood function **with daily aggregated trading volume**.
  - Due to space limitations, this table present parameters for the first semester in each year
- The standard errors reveal that the parameters are estimated with reasonable precision.
- Parameters substantially change over time.

Results

Table. Model specification tests in terms of migration and liquidity setups

Year	Unrestric. model	Restric. Model $\alpha=0$		Restric. Model $\eta=0$		Restric. Model $\alpha=0$; $\eta=0$	
	Likelih. ratio	Likelih. ratio	χ^2	Likelih. ratio	χ^2	Likelih. Ratio	χ^2
1° 2007	-1636.1	-2156.1	1040.1	-1386.3	-499.56	-1718.5	164.78
2° 2007	-1208.5	-1376.4	335.87	-1270.1	123.13	-1523.3	629.66
1° 2008	-1242.6	-1337.5	189.89	-1298.9	112.63	-1666.8	848.41
2° 2008	-1417.2	-1514.2	193.93	-1232.1	-370.2	-1631.6	428.80
1° 2009	-1252.9	-2290.3	2074.8	-1192.5	-120.9	-1825.1	1144.40
2° 2009	-1471.6	-1828.3	713.32	-1704.7	466.18	-2083.8	1224.30
1° 2010	-1215.7	-1364.2	296.9	-1347	262.56	-1678.1	924.68
2° 2010	-1197.3	-1803.9	1213.2	-1280.1	165.61	-1531.3	667.99
1° 2011	-1334	-1951.1	1234.1	-1328.2	-11.652	-1647.5	626.85
2° 2011	-1284.9	-1169.1	-231.5	-1125.7	-318.39	-1341.7	113.68
1° 2012	-1136.3	-1141.6	10.689	-1120.6	-31.311	-1541.2	809.87
2° 2012	-1104.7	-1147.1	84.698	-1138.9	68.321	-1490.2	770.97
1° 2013	-1174.7	-1239	128.61	-1218.6	87.872	-1358.09	366.78
2° 2013	-1174.8	-1196.3	42.988	-1187.7	25.91	-1450.2	550.83

- The log-likelihood values of other money market specifications are significantly in general smaller than the in the unrestricted model.

Results

- We calculate posterior probabilities, using the Bayes rule, with estimated parameters and daily volume data in each market.
  - Thus, we can obtain daily measures of money market interaction.

- E.g., the posterior probability of a migration from CM to UM on a day i is:

$$P_i(UM \rightarrow CM|(UM_i, CM_i), \hat{\varphi};) = \frac{P_i((UM_i, CM_i)|NoMig, \hat{\varphi})P_i(NoMig|\hat{\varphi})}{P_i((UM_i, CM_i)|\hat{\varphi})}$$

where the parameters estimated in each semester are:

$$\hat{\varphi} \equiv (\hat{\alpha}, \hat{\delta}, \hat{\eta}, \hat{\theta}, \hat{\xi}_{UM}, \hat{\xi}_{CM}, \hat{\mu}_{UM\downarrow}, \hat{\mu}_{CM\uparrow}, \hat{\mu}_{UM\uparrow}, \hat{\mu}_{CM\downarrow}, \hat{\lambda}_{UM\downarrow}, \hat{\lambda}_{CM\downarrow}, \hat{\lambda}_{UM\uparrow}, \hat{\lambda}_{CM\uparrow})$$

Results

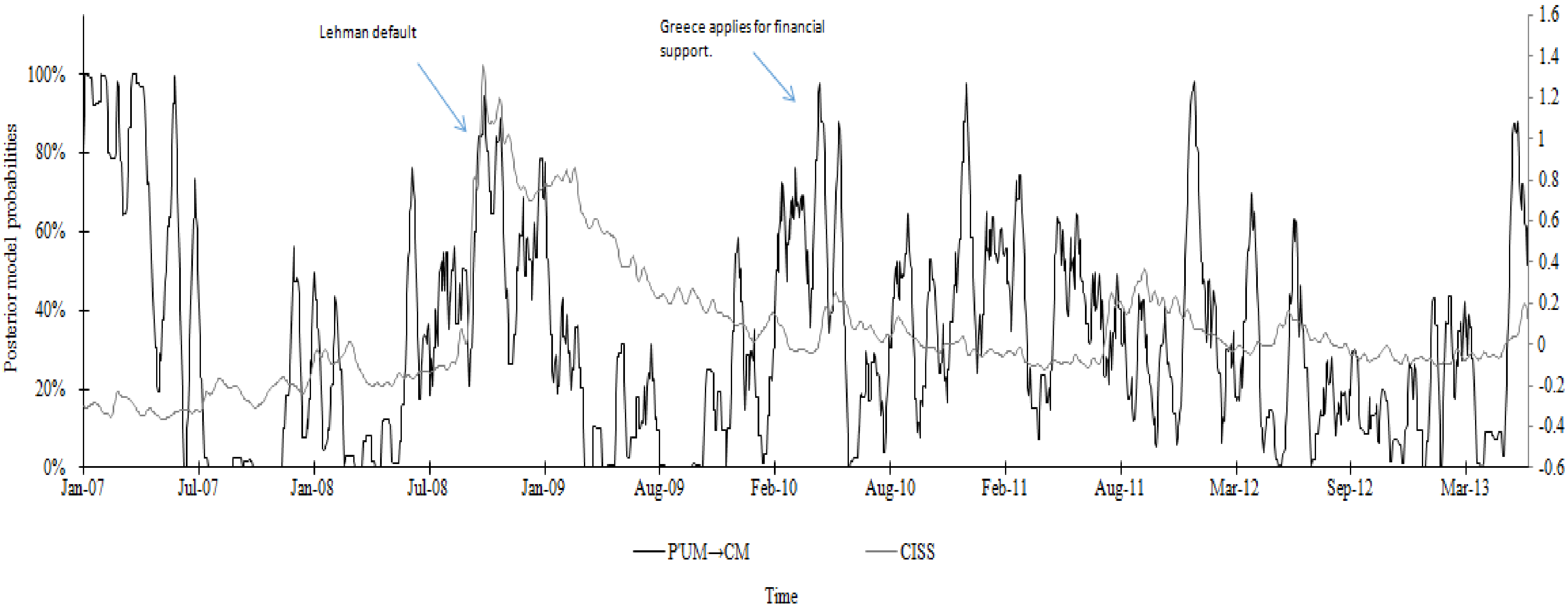


Fig. Evolution of the posterior probabilities of migration.

- The probability of migration UM→CM in some periods is moving in a similar way as CISS.
- However, probability of migration UM→CM in other periods is moving quite differently to CISS.
  - **$P_{UM \rightarrow CM}$ provides some additional information**

Results

- **Important:**
  - We estimate the structural model with only trading volume data.

- Nevertheless, information captured by our model should explain the behavior of money markets in terms of interest rates

    - If this is not the case, there is something wrong: 

    - If this is the case, it is a good check for our model: 

- However, if our model capture new information, this information has to be significant after adding as controls:
  - Controls for the level of demand of collateral
    - Measures of systemic stress.
    - Measures of flight-to-liquidity
    - Volume in each segments.

Results

	Dependent Variable: $r_{UM,t}$				Dependent Variable: $r_{CM,t}$			
$P'_{CM\rightarrow UM,t\text{-}1}$	.034**	.051***			-.035*	-.032		
$P'_{UM\rightarrow CM,t\text{-}1}$			.014	.001			.061***	.122***
$P'_{liq+,t\text{-}1}$	.091***		.086***		.193***		.172***	
$P'_{liq-,t\text{-}1}$		-.108***		-.099***		-.023		.031
$CISS_{t\text{-}1}$	.052*	.124***	.041*	.111***	-.883***	-.840***	-.925***	-.979***
$Ln\,(Vol_{t\text{-}1})$	-.065***	-.061***	-.063***	-.060***	-.047***	-.045**	-.051***	-.060***
$FlightLiq_{t\text{-}1}$	.087***	.082***	.083***	.080***	.068*	.0175	.052	-.012
const.	.828***	.812***	.798***	.807***	.713***	.747**	.765***	.929***
$Adj.\ R^2$	.222	.241	.217	.225	.409	.192	.401	.215

- Systemic risk increases r_{UM} (reduces r_{CM}):
  - In UM, banks increases the rates to account for the possibility of default
  - In CM banks are willing to reduce interest rates to find “good-quality” collaterals in bad times

Results

	Dependent Variable: $r_{UM,t}$				Dependent Variable: $r_{CM,t}$			
$P'_{CM\to UM,t-1}$	.034**	.051***			-.035*	-.032		
$P'_{UM\to CM,t-1}$			.014	.001			.061***	.122***
$P'_{liq+,t-1}$	.091***		.086***		.193***		.172***	
$P'_{liq-,t-1}$		-.108***		-.099***		-.023		.031
$CISS_{t-1}$	.052*	.124***	.041*	.111***	-.883***	-.840***	-.925***	-.979***
$Ln\,(Vol_{t-1})$	-.065***	-.061***	-.063***	-.060***	-.047***	-.045**	-.051***	-.060***
$FlightLiq_{t-1}$	.087***	.082***	.083***	.080***	.068*	.0175	.052	-.012
const.	.828***	.812***	.798***	.807***	.713***	.747**	.765***	.929***
$Adj.\ R^2$	.222	.241	.217	.225	.409	.192	.401	.215

- Controlling by other risks (such as systemic risk, liquidity and flight to liquidity), additional lending in UM (CM), due to a reduction (increase) in collateral supply, increases interest rates:
  - Additional lending demand, in each funding channel, increases interest rates

Results

	Dependent Variable: *Network Centrality* $_{UM}$				Dependent Variable: *Network Centrality* $_{CM}$			
$P'_{CM \rightarrow UM,t\text{-}1}$	.007***	.010***			-.007***	-.005***		
$P'_{UM \rightarrow CM,t\text{-}1}$			-.002	-.006***			.006***	.006***
$P'_{liq+,t\text{-}1}$	.006**		.006***		.019***		.018***	
$P'_{liq-,t\text{-}1}$		-.016***		-.018***		-.012***		-.010***
$CISS_{t\text{-}1}$	.036***	.046***	.036***	.049***	-.006*	.003	-.007**	-.002
$Ln(Vol_{t\text{-}1})$	-.007***	-.006***	-.006***	-.006***	-.000	-.000	-.000	-.000
$FlightLiq_{t\text{-}1}$	.001	.003	.002	.004**	.003**	.001	.002	-.001
const.	.170***	.158***	.171***	.167***	.051***	.054***	.043***	.054***
$Adj.\ R^2$	.266	.366	.242	.339	.409	.192	.401	.215

- Systemic risk increases (reduces) centrality in UM (CM)
  - In UM ,banks search protection in partners (i.e. center).
  - In CM, banks search protection in safe collaterals (which are not necessary in the center)

Results

	Dependent Variable: *Network Centrality* $_{UM}$				Dependent Variable: *Network Centrality* $_{CM}$			
$P'_{CM\rightarrow UM,t-1}$	.007***	.010***			-.007***	-.005***		
$P'_{UM\rightarrow CM,t-1}$			-.002	-.006***			.006***	.006***
$P'_{liq+,t-1}$	.006**		.006***		.019***		.018***	
$P'_{liq-,t-1}$		-.016***		-.018***		-.012***		-.010***
$CISS_{t-1}$	.036***	.046***	.036***	.049***	-.006*	.003	-.007**	-.002
$Ln(Vol_{t-1})$	-.007***	-.006***	-.006***	-.006***	-.000	-.000	-.000	-.000
$FlightLiq_{t-1}$	.001	.003	.002	.004**	.003**	.001	.002	-.001
const.	.170***	.158***	.171***	.167***	.051***	.054***	.043***	.054***
$Adj.\ R^2$	.266	.366	.242	.339	.409	.192	.401	.215

- Controlling by other risks (such as systemic risk, market volume and flight to liquidity), additional lending in UM (CM), due to a reduction (increase) of collateral supply, is first with partners at the core of the network.

Results

	Dependent Variable: *Lending Volume with 3 Most Used Colaterals* $_{t-1}$			
$P'_{CM \rightarrow UM,t-1}$	.049**	.0402*		
$P'_{UM \rightarrow CM,t-1}$			-.085***	-.081***
$P'_{liq+,t-1}$	-.044**		-.014	
$P'_{liq-,t-1}$		.053**		.020
$CISS_{t-1}$	.216***	.182**	.276***	.261***
$Ln(Vol_{t-1})$	.066***	.066***	.073***	.072***
$FlightLiq_{t-1}$	-.096***	-.093***	-.073***	-.074***
const.	-.311**	-.320**	-.382***	-.386***
$Adj.\ R^2$	.121	.124	.147	.148

- In the case of high levels of systemic risk, banks in CM search protection specific types of collateral (which are not necessary in the center).

Results

	Dependent Variable: *Lending Volume with 3 Most Used Colaterals* $_{t\text{-}1}$			
$P'_{CM \rightarrow UM,t\text{-}1}$	.049**	.0402*		
$P'_{UM \rightarrow CM,t\text{-}1}$			-.085***	-.081***
$P'_{liq+,t\text{-}1}$	-.044**		-.014	
$P'_{liq-,t\text{-}1}$		.053**		.020
$CISS_{t\text{-}1}$	.216***	.182**	.276***	.261***
$Ln\,(Vol_{t\text{-}1})$	.066***	.066***	.073***	.072***
$FlightLiq_{t\text{-}1}$	-.096***	-.093***	-.073***	-.074***
const.	-.311**	-.320**	-.382***	-.386***
$Adj.\ R^2$	.121	.124	.147	.148

- Controlling by other risks (such as systemic risk, volume and flight to liquidity), additional lending in CM, due to a augment in collateral supply, is <u>with different types of collaterals</u>.

Conclusions

- We introduce a structural model that captures, using market data, the evolution of the collateral supply in money markets.

- The evolution of the collateral supply is obtained taking into account the interaction in unsecured and collateralized lending segments.

- We report that migration probabilities and probabilities of liquidity shocks evolve over time.

- The information contained in money marker interactions (and captured by our model) explain money market characteristics:
  - Interest rates, centrality measures, and collateral concentration
  - Even, after controlling for systemic risk, market volume and measures of flight-to-liquidity