

# ESTIMATING THE IMPACT OF LOAN SUPPLY SHOCKS

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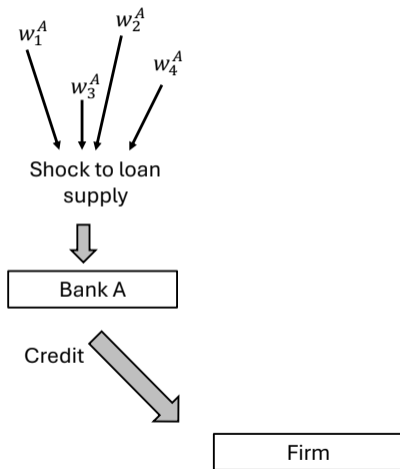
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# MOTIVATION AND SETUP

- Disruptions to the financial sector viewed as a key driver of economic activity, business cycles, severity of financial crises, monetary policy transmission, etc
- Understanding the impact of loan supply shocks – both on lending and on real outcomes – is thus a fundamental economic question
- At the heart of a vast literature in both finance and macroeconomics
  - Bernanke & Blinder (1988), Bernanke & Gertler (1995), Kashyap & Stein (1995)

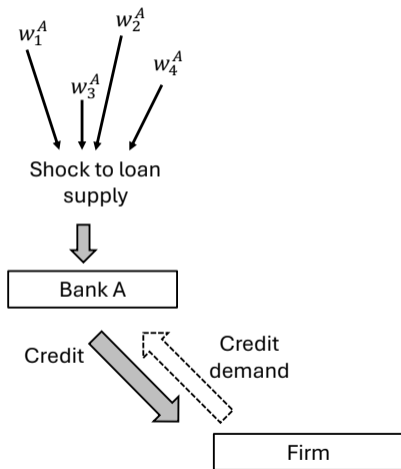
# WHAT DO WE WANT TO ESTIMATE?

- $w$ 's are shifters to loan supply
  - Deposit drawdowns
  - Credit line drawdowns
  - Losses due to risky securities
  - Regulatory changes (e.g. risk weights), etc



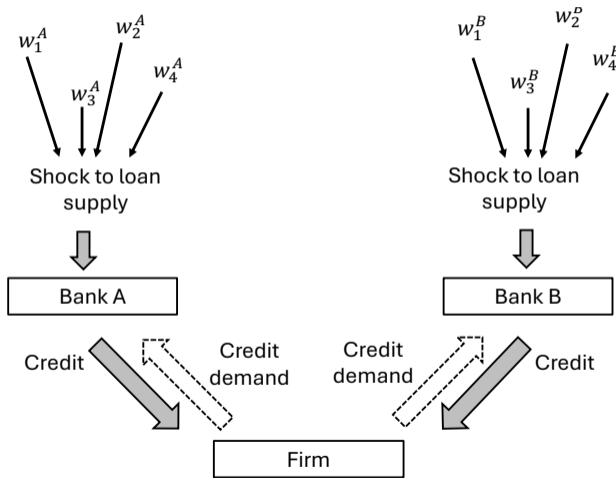
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  - Regulatory changes (e.g. risk weights), etc
- Main problem: correlation between loan supply and loan demand effects!
- Key insight in literature: look at firms borrowing from more than one bank



# WHAT DO WE WANT TO ESTIMATE?

- Two separate margins to consider in estimating how **lending** responds to **loan supply shocks**
- **Lending margin**: loan-level vs. firm-level
  - Loan-level effect: how does a **bank's lending** to the firm vary when the bank experiences a supply shock?
  - Firm-level effect: how does **total firm borrowing**, across all its banks, vary with supply shocks?
- **Loan supply margin**: **specific** loan supply shifter vs. **total** loan supply effect
  - Specific shifter effect: how does a specific shifter of loan supply affect lending?
  - Total supply shock effect: what is the impact of *all* supply shocks experienced by a bank?

# WHAT DO WE WANT TO ESTIMATE? 4 OBJECTS OF INTEREST

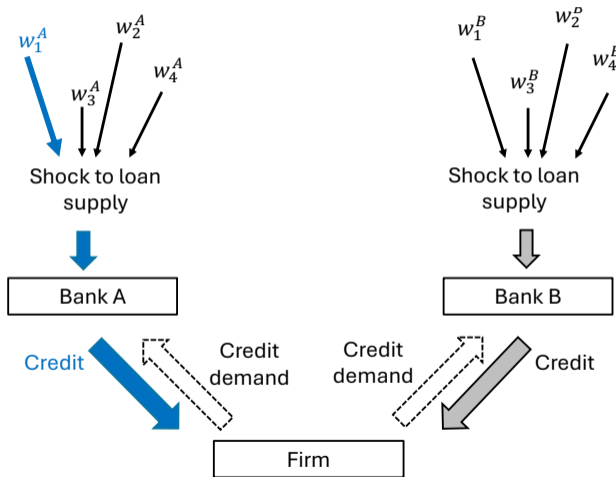
Impact on:

Impact of:

	Single Bank's Lending to Firm	Total Lending to Firm
Particular Loan Supply Shifter		
Total Loan Supply Shock		

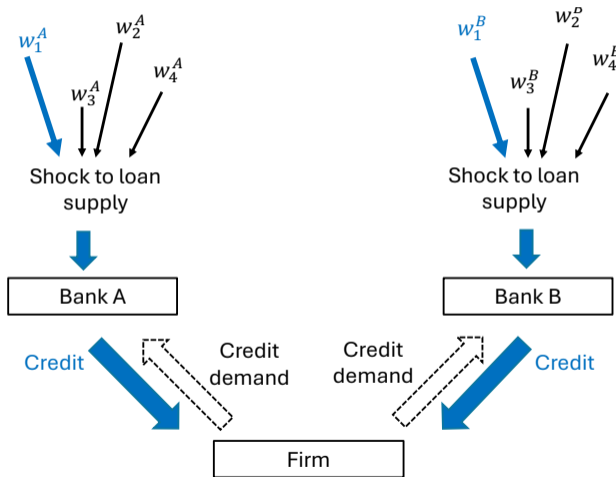
# WHAT DO WE WANT TO ESTIMATE? 4 OBJECTS OF INTEREST

- What is impact on **loan-level** lending to the firm stemming from a **specific supply shifter** experienced by a bank?



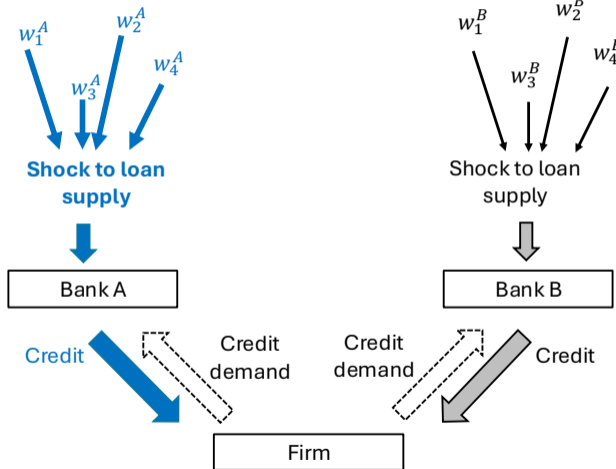
# WHAT DO WE WANT TO ESTIMATE? 4 OBJECTS OF INTEREST

- What is impact on **total firm borrowing** stemming from a **specific supply shifter** experienced by its banks?



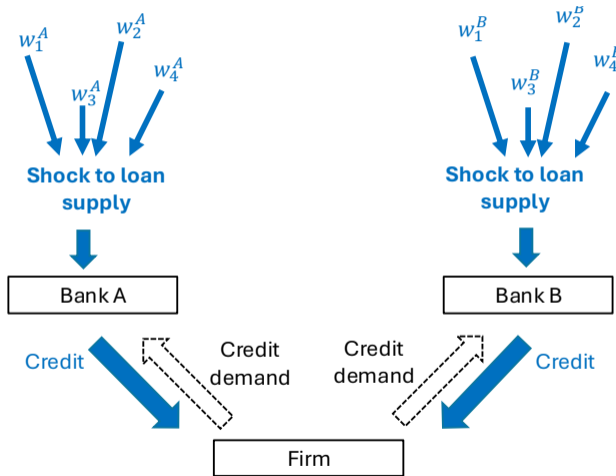
# WHAT DO WE WANT TO ESTIMATE? 4 OBJECTS OF INTEREST

- What is impact on **loan-level** lending to the firm stemming from **all supply shocks** experienced by a bank?



# WHAT DO WE WANT TO ESTIMATE? 4 OBJECTS OF INTEREST

- What is impact on **total firm borrowing** from **all supply shocks** experienced by its banks?



## THE FOUR OBJECTS OF INTEREST

**Thus, in estimating lending impact of loan supply shocks, four objects of interest:**

- Impact on **loan-level lending** to the firm stemming from a **specific supply shifter** experienced by a bank
- Impact on **loan-level lending** to the firm stemming from **all supply shocks** experienced by a bank
- Impact on **total firm-level borrowing** stemming from a **specific supply shifter** experienced by its banks
- Impact on **total firm-level borrowing** stemming from **all supply shocks** experienced by its banks

## TWO MAIN APPROACHES TO ESTIMATION IN THE LITERATURE

- **Main insight:** use firms borrowing from more than one bank to disentangle supply and demand effects
- Khwaja-Mian (2008) fixed effects regression ("KM regression"), where  $w_j$  is loan supply shifter:

$$\Delta \log L_{ij} = \beta_{KM} w_j + \delta_i + \epsilon_{ij}$$

- Amiti-Weinstein (2018) bank and firm fixed effect regressions ("AW"):

$$\Delta \log L_{ij} = \phi_i + \zeta_j + v_{ij}$$

then running real effects regression of form:  $y_i = \gamma_0 + \gamma_s \bar{\zeta}_i + \gamma_d \phi_i + e_i$

## WHAT WE DO IN THIS PAPER

- Build micro-founded theoretical framework with standard ingredients to discipline empirical analysis and derive the four objects of interest
- Show that **neither** of the main empirical methods estimate any of the target four objects:
  - KM estimator is an elasticity of substitution
  - Bank fixed effects capture supply-side effects, but incorrectly scaled (by the elasticity of substitution)
  - Firm fixed effects capture demand-side effects but also supply-side effects
- Show how to **estimate all four objects** of interest
- Apply this methodology to the 2011 credit crisis in Spain

# RELATED LITERATURE

## CREDIT SUPPLY SHOCKS

- Many papers use KM (2008) and AW (2018) to isolate the effect of the bank lending channel and quantify the real effects

### **A partial list:**

- Estimating the bank lending channel: Khwaja & Mian (2008), Paravisini (2008), Iyer et al. (2014), Jimenez et al. (2012), Iyer et al. (2014)
- Real effects of lending shocks: Chodorow-Reich (2014), Amiti & Weinstein (2018), Jimenez et al. (2020), Alfaro et al. (2020)

## BASIC INTUITION: IT'S AN ELASTICITY OF SUBSTITUTION

- The KM estimator:  $\Delta \log L_{ij} = \beta_{KM} w_j + \delta_i + \epsilon_{ij}$
- Interpreted as: "*a standard deviation increase in [loan supply shifter] reduces bank lending by x%*". I.e., loan-level impact of supply shifter...
- But standard interpretation incorrect: take difference in  $\Delta \log L_{ij}$  within the firm

$$\Delta \log \left( \frac{L_{i2}}{L_{i1}} \right) = \beta_{KM} (w_2 - w_1) + (\epsilon_{i2} - \epsilon_{i1})$$

**showing that  $\beta_{KM}$  captures the elasticity of substitution**

- Bank fixed effect in AW regressions will also capture this EOS effect
- This argument is model independent

# PLAN FOR THIS TALK

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# MODEL SETUP

- A firm with no internal wealth borrowing from  $N = 2$  banks to invest in a project
  - Borrowing and investing  $L = L_1 + L_2$  from the two banks yields a present value  $R(L)$
- Raising external finance is costly, with the deadweight cost associated with raising an amount  $L_j$  from bank  $j$  equal to  $c(L_j) = a_j L_j^\rho$ , with  $\rho > 1$ 
  - Changes in  $a_j$  capture shifts in bank-level loan supply: shifts firm's cost of external finance
- Firm maximizes:

$$\begin{aligned} \max_{L_1, L_2} & \{R(L_1 + L_2) - (L_1 + L_2) - \tilde{C}(L_1, L_2)\} \\ & \text{with } \tilde{C}(L_1, L_2) = (a_1 L_1^\rho + a_2 L_2^\rho). \end{aligned}$$

# THE ELASTICITY OF SUBSTITUTION

- Useful to write this as two step optimization with cost minimization function:

The firm chooses total borrowing,  $L$ :

$$\max_L \{R(L) - L - C(L)\},$$

with  $C(L)$ , the cost minimization function:

$$C(L) := \min_{L_1, L_2} \{a_1 L_1^\rho + a_2 L_2^\rho \mid L_1 + L_2 = L\}$$

- The **elasticity of substitution (EOS)** of  $1/(\rho - 1)$  is direct from the FOCs:

$$\log\left(\frac{L_1}{L_2}\right) = -\frac{1}{\rho - 1} \log\left(\frac{a_1}{a_2}\right)$$

## THE IMPACT OF SUPPLY SHOCKS ON TOTAL FIRM BORROWING

- Denote log changes between  $t + 1$  and  $t$  with  $\Delta$ , and log-linearize the FOC to get the impact on total firm borrowing:

$$\Delta \log L \approx \theta (s_1 \Delta \log a_1 + s_2 \Delta \log a_2)$$

where  $s_j = \frac{L_j}{L}$  is the pre-shock lending share of bank  $j$ .

- **The total firm borrowing elasticity  $\theta$** : response of total firm borrowing to weighted average change in lending costs across its banks

# WHAT DETERMINES THE TOTAL FIRM BORROWING ELASTICITY $\theta$ ?

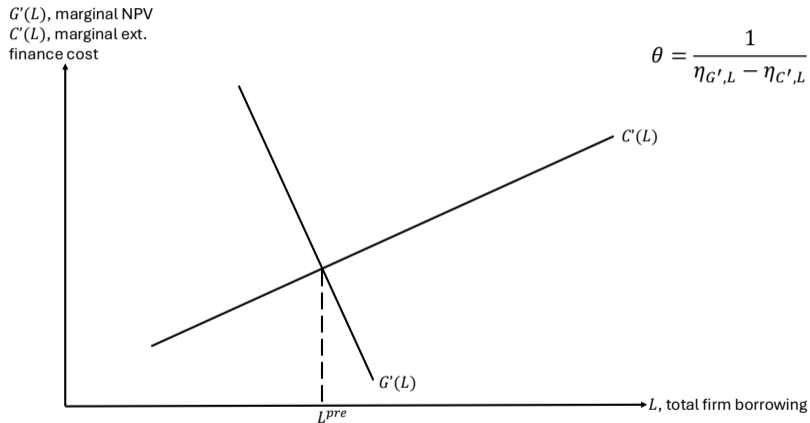
- Using our model, we show:

$$\theta = \frac{1}{\eta_{G,L} - \eta_{C,L}} < 0$$

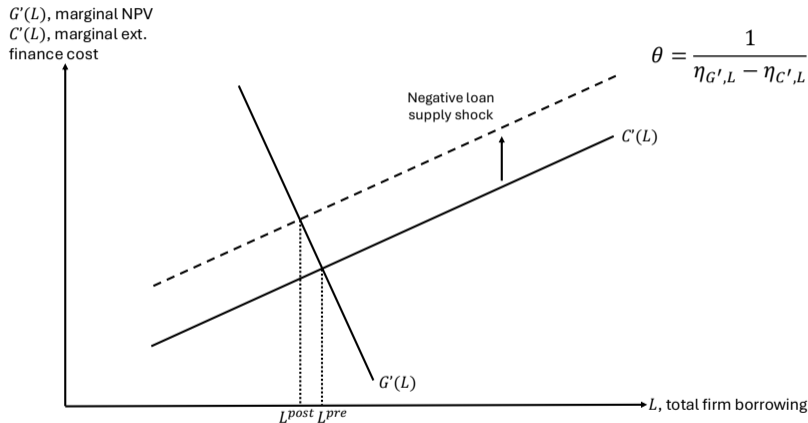
where:

- $G(L) = R(L) - L$ , first best NPV of investment (net of ext. financing cost)
- $\eta_{G,L}$  the partial elasticity of marginal NPV to  $L$
- $\eta_{C,L}$  the partial elasticity of marginal external finance cost to  $L$

# WHAT DETERMINES THE TOTAL FIRM BORROWING ELASTICITY $\theta$ ?

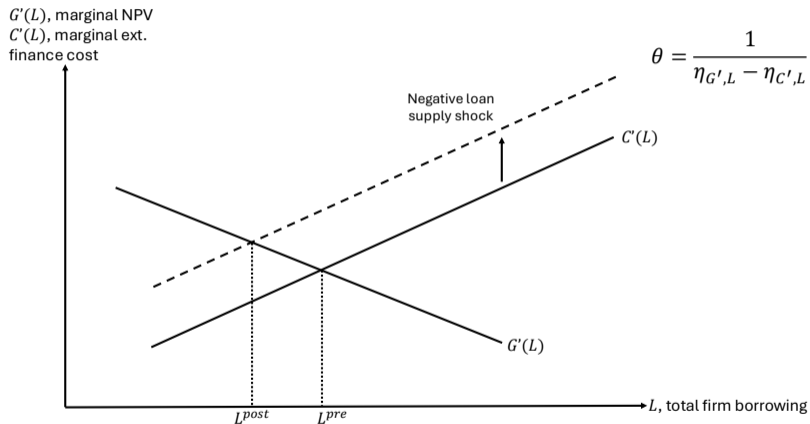


# WHAT DETERMINES THE TOTAL FIRM BORROWING ELASTICITY $\theta$ ?



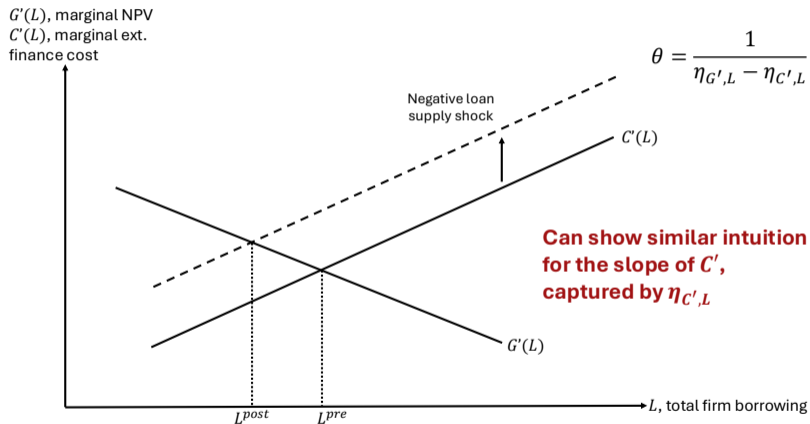
Large  $\eta_{G',L}$  (Steep  $G'(L)$ ): demand for credit relatively **inelastic**  $\Rightarrow$  small responses

# WHAT DETERMINES THE TOTAL FIRM BORROWING ELASTICITY $\theta$ ?



Small  $\eta_{G',L}$  (flat  $G'(L)$ ): demand for credit relatively **elastic**  $\Rightarrow$  large responses

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## WHAT DETERMINES THE TOTAL FIRM BORROWING ELASTICITY $\theta$ ?

- Can also show:

$$\theta = \frac{1}{\eta_{G,L} - \eta_{C,L}} = \frac{1}{\left(\frac{1+C'}{C'}\right)\eta_{R,L} - \eta_{C,L}}$$

What is  $\frac{C'}{1+C'}$ ?

$$\frac{C'}{1+C'} = \frac{\text{marginal external finance costs}}{\text{total marginal costs}}$$

- Measure of relative importance of cost of external finance
- **As relative importance of external finance declines to zero, elasticity of total firm borrowing to average supply shock experienced by its banks vanishes:  $\theta \rightarrow 0$**

## THE LOAN-LEVEL EFFECT: THE SCALE-SUBSTITUTION EQUATION

- Log-linearize the FOC to get the response of lending from bank  $j$  to changes in the cost of external finance:

$$\Delta \log L_j \approx \underbrace{\theta (s_1 \Delta \log a_1 + s_2 \Delta \log a_2)}_{\text{Scale Effect}} - \underbrace{\frac{1}{\rho - 1} s_{-j} \Delta \log \left( \frac{a_j}{a_{-j}} \right)}_{\text{Substitution Effect}}$$

- **Scale effect:** captures the impact of weighted average bank-level loan supply shocks experienced by the firm's banks
- **Substitution effect:** when relative cost of lending from Bank  $j$  increases,  $L_j$  declines

## LOAN- VS. FIRM-LEVEL LENDING RESPONSES

- Can re-write the scale-substitution equation to obtain the **loan-level response** to bank supply shock,  $\Delta \log(a_1)$ :

$$\Delta \log L_1 \approx \left( \theta s_1 - \frac{1}{\rho-1} s_2 \right) \Delta \log a_1 + \left( \theta s_2 + \frac{1}{\rho-1} s_2 \right) \Delta \log a_2$$

- Determined by **both** scale ( $\theta s_1$ ) and substitution ( $-\frac{1}{\rho-1} s_2$ ) effects

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- Determined by **both** scale ( $\theta s_1$ ) and substitution ( $-\frac{1}{\rho-1} s_2$ ) effects
- As bank hit by shock is more important ( $s_1$  rises), loan-level lending effect governed by scale effect
- Naturally, shocks to bank 2 also affect lending from bank 1

## INTRODUCING SPECIFIC LOAN SUPPLY SHIFTER

- Till this point, considered shifts in cost of external finance,  $\Delta \log a_j$ 
  - But these are not observable
- Assume that  $w_j$  is an observable, bank-level shifter to loan supply
  - Deposits drawdown / exposure to interbank lending market / exposure to risky stock...
- Use a linear projection to relate total change in cost,  $\Delta \log a_j$ , to the shifter,  $w_j$ :

$$\Delta \log a_j = b_0 + b_1 w_j + \chi_j$$

- The loan-level equation becomes:

$$\Delta \log L_j \approx \text{constant} + \left( b_1 \theta s_j - \frac{b_1}{\rho - 1} s_{-j} \right) w_j + \left( b_1 \theta s_{-j} + \frac{b_1}{\rho - 1} s_{-j} \right) w_{-j} + \tilde{\chi}_j$$

- The firm-level equation becomes:

$$\Delta \log L \approx \text{constant} + b_1 \theta (s_1 w_1 + s_2 w_2) + \tilde{\chi}$$

## SUMMARY OF THE FOUR OBJECTS OF INTEREST

- Impact on **loan-level lending** to the firm stemming from **a specific supply**

$$\Delta \log L_j \approx \text{constant} + \left( b_1 \theta s_j - \frac{b_1}{\rho - 1} s_{-j} \right) w_j + \left( b_1 \theta s_{-j} + \frac{b_1}{\rho - 1} s_{-j} \right) w_{-j} + \tilde{\chi}_j$$

- Impact on **total firm-level borrowing** stemming from **a specific supply shifter**

$$\Delta \log L \approx \text{constant} + b_1 \theta (s_1 w_1 + s_2 w_2) + \tilde{\chi}$$

- Impact on **loan-level lending** to the firm stemming from **all supply shocks**

$$\Delta \log L_1 \approx \left( \theta s_1 - \frac{1}{\rho - 1} s_2 \right) \Delta \log a_1 + \left( \theta s_2 + \frac{1}{\rho - 1} s_2 \right) \Delta \log a_2$$

- Impact on **total firm-level borrowing** stemming from **all supply shocks**

$$\Delta \log L \approx \theta (s_1 \Delta \log a_1 + s_2 \Delta \log a_2)$$

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# THE ECONOMETRIC FRAMEWORK

- Add random component to the borrowing cost functions:  $c_j(L_{ijt}) = a_{jt} u_{ijt} L_{ijt}^\rho$ 
  - $u_{ijt}$  captures a random time  $t$  bank-firm level component of borrowing costs
- On the demand side, present value function:  $R_{it}(L_{it}) = B_{it} \tilde{R}(L_{it})$ 
  - $B_{it}$  is time varying, firm-specific parameter that shifts investment opportunities
- Get the empirical counterpart of the total firm borrowing and the loan-level equations:

$$\Delta \log L_i = \text{constant} + \underbrace{\Delta \log \tilde{B}_i}_{x_{d,i}^*} + \underbrace{\theta (s_{i1} \Delta \log a_1 + s_{i2} \Delta \log a_2)}_{x_{s,i}^*} + \tilde{v}_i$$

$$\Delta \log L_{ij} = \text{constant} + \underbrace{\Delta \log \tilde{B}_i}_{x_{d,i}^*} + \underbrace{\left( s_{i,j} \theta - s_{i,-j} \frac{1}{\rho - 1} \right) \Delta \log a_j}_{x_{s,i,j}^*} + \underbrace{\left( s_{i,-j} \theta + s_{i,-j} \frac{1}{\rho - 1} \right) \Delta \log a_{-j}}_{x_{s,i,-j}^*} + v_{ij}$$

- Similar derivations apply for the specific loan supply shifter equations

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## KM THROUGH THE LENS OF THE MODEL

- Recall the KM estimator:

$$\Delta \log L_{ij} = \beta_{KM} w_j + \delta_i + \epsilon_{ij}$$

- Back to the model, log change in lending from bank  $i$  to firm  $j$  is:

$$\Delta \log L_{ij} = \text{constant} + \frac{1}{(\rho - 1)} \Delta \log(B_i \tilde{R}'(L_i) - 1) - \frac{b_1}{(\rho - 1)} w_j - \frac{1}{(\rho - 1)} (\Delta \log u_{ij} + \chi_j)$$

- Assuming  $\Delta \log u_{ij} \perp w_j \rightarrow$  firm fixed effects absorb the firm-specific component and:

$$\beta_{KM} = -\frac{b_1}{\rho - 1}$$

- KM captures the (scaled) elasticity of substitution in borrowing between banks**
  - Scaling factor  $b_1$ : the transmission coefficient between the supply shifter ( $w_j$ ) and the bank level cost of external finance ( $a_j$ )

## COMPARING KM ESTIMATOR TO DESIRED ESTIMATORS

- Given  $b_1 > 0$ , under mild assumptions ( $R(L)$  concave) have that:

$$\underbrace{-\frac{b_1}{\rho-1}}_{\beta_{KM}} < \underbrace{b_1\theta s_j - \frac{b_1}{\rho-1}s_{-j}}_{\text{Loan-level lending elasticity}} < \underbrace{b_1\theta}_{\text{Firm-level lending elasticity}} < 0$$

- KM regression **overestimates**
  - magnitude of the elasticity of **loan-level lending** to the loan-supply shifter
  - magnitude of the elasticity of **total firm-level lending** to the loan-supply shifter

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## AW THROUGH THE LENS OF THE MODEL

- Run log change in lending from bank  $j$  to firm  $i$ , on firm FE and bank FE:

$$\Delta \log L_{ij} = \phi_i + \zeta_j + v_{ij}$$

In the literature common to see:

Firm FE: "captures firm-level demand"

Bank FE: "captures bank-level loan supply shock"

- Back to the model:

$$\Delta \log L_{ij} = \underbrace{\frac{1}{(\rho - 1)} \Delta \log(B_i \tilde{R}'(L_i) - 1)}_{\text{Corresponds to Firm FE, } \phi_i} - \underbrace{\frac{1}{(\rho - 1)} \Delta \log a_j}_{\text{Corresponds to Bank FE, } \zeta_j} - \frac{1}{(\rho - 1)} \Delta \log u_{ij}$$

## AW THROUGH THE LENS OF THE MODEL

- Let's write this using the  $a_j$  supply shock terms, and without the endogenous  $L_i$  object:

$$\begin{aligned} \Delta \log L_{ij} &= \text{constant} + \underbrace{\Delta \log \tilde{B}_i}_{x_{d,i}^*} + \underbrace{\left( s_{i,j}\theta - s_{i,-j} \frac{1}{\rho-1} \right) \Delta \log a_j}_{x_{s,i,j}^*} + \underbrace{\left( s_{i,-j}\theta + s_{i,-j} \frac{1}{\rho-1} \right) \Delta \log a_{-j}}_{x_{s,i,-j}^*} + v_{ij} \\ &= \text{constant} + \underbrace{\Delta \log \tilde{B}_i + \left( \theta + \frac{1}{\rho-1} \right) \left( s_{i,j} \Delta \log a_j + s_{i,-j} \Delta \log a_{-j} \right)}_{\phi_i, \text{ Firm FE}} + \underbrace{\left( -\frac{1}{\rho-1} \Delta \log a_j \right)}_{\zeta_j, \text{ Bank FE}} + v_{ij} \end{aligned}$$

- Firm FE: Contain shocks to demand, **but also changes in supply**, as optimal firm borrowing,  $L_i$ , depends on costs of external finance from each bank,  $a_1$  and  $a_2$ !
- Bank FE: Correspond to shocks to loan supply,  $\Delta \log a_j$ , but **are scaled incorrectly**

Misallocating supply and demand effects has implications for two important applications:

- 1 Aggregation (to bank/economy level) of lending changes into supply versus demand driven changes **misattributes firm-level supply changes to the demand channel** rather than the supply channel
- 2 Real effect regressions, using  $\bar{\zeta}_i := s_{1,i}\zeta_1 + s_{2,i}\zeta_2$  and controlling for the firm fixed effects,  $\phi_i$ , **yield biased estimates for the impact of loan supply shocks on real outcomes**

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## ESTIMATING THE FOUR OBJECTS OF INTEREST

- Impact on **loan-level lending** to the firm stemming from **a specific supply**

$$\Delta \log L_j \approx \text{constant} + \left( b_1 \theta s_j - \frac{b_1}{\rho - 1} s_{-j} \right) w_j + \left( b_1 \theta s_{-j} + \frac{b_1}{\rho - 1} s_{-j} \right) w_{-j} + \Delta \log \tilde{B}_i + v_{i,j} + \tilde{\chi}_{i,j}$$

- Impact on **total firm-level borrowing** stemming from **a specific supply shifter**

$$\Delta \log L \approx \text{constant} + b_1 \theta (s_1 w_1 + s_2 w_2) + \Delta \log \tilde{B}_i + \tilde{v}_{i,j} + \tilde{\chi}_i$$

- Impact on **loan-level lending** to the firm stemming from **all supply shocks**

$$\Delta \log L_1 \approx \left( \theta s_1 - \frac{1}{\rho - 1} s_2 \right) \Delta \log a_1 + \left( \theta s_2 + \frac{1}{\rho - 1} s_2 \right) \Delta \log a_2 + \Delta \log \tilde{B}_i + v_{i,j}$$

- Impact on **total firm-level borrowing** stemming from **all supply shocks**

$$\Delta \log L \approx \theta (s_1 \Delta \log a_1 + s_2 \Delta \log a_2) + \Delta \log \tilde{B}_i + \tilde{v}_{i,j}$$

# 1. ESTIMATING THE SCALE EFFECT

- Consider empirical counterpart of scale-substitution equation (*can't run this*):

$$\Delta \log L_{i,j} = \delta_0 + b_1 \theta (s_{i,1} w_1 + s_{i,2} w_2) - \frac{b_1}{(\rho - 1)} s_{i,-j} (w_j - w_{-j}) + \Delta \log \tilde{B}_i + v_{i,j} + \tilde{\chi}_{i,j}$$

- *Can* estimate following scale-substitution regression:

$$\Delta \log L_{i,j} = d_0 + d_1 \underbrace{(s_{i,1} w_1 + s_{i,2} w_2)}_{x_{i,j,1}} + d_2 \underbrace{s_{i,-j} (w_j - w_{-j})}_{x_{i,j,2}} + e_{i,j}$$

- Assuming  $cov(x_{i,j,2}, v_{i,j} + \tilde{\chi}_{i,j}) = 0$ , can obtain consistent estimate of  $b_1 \theta$ :
  - $d_2$  inconsistent for  $-\frac{b_1}{\rho-1}$ , with bias function of  $cov(x_{i,j,1}, e_{i,j})$ ,  $cov(x_{i,j,1}, x_{i,j,2})$
  - **But,  $\beta_{KM}$  is consistent for  $-\frac{b_1}{\rho-1}$ : Compare  $\hat{\beta}_{KM}$  and  $\hat{d}_2$  to estimate  $cov(x_{i,j,1}, e_{i,j})$ , then use it to correct  $\hat{d}_1$  to estimate  $b_1 \theta$**

# 1. ESTIMATING THE SCALE EFFECT – FORMALIZATION

- Run

$$\Delta \log L_{i,j} = d_0 + d_1 \underbrace{(s_{i,1} w_1 + s_{i,2} w_2)}_{x_{i,j,1}} + d_2 \underbrace{s_{i,-j} (w_j - w_{-j})}_{x_{i,j,2}} + e_{i,j}$$

$$\Delta \log \left( \frac{L_{i2}}{L_{i1}} \right) = \beta_{KM} (w_2 - w_1) + \varepsilon_{ij}$$

$$x_{i,j,2} = \delta_0 + \delta_{x_2, x_1} x_{i,j,1} + r_{i,j}$$

- We show the following:

$$\widehat{d}_1 - \frac{1}{\widehat{\delta}_{x_2, x_1}} (\widehat{\beta}_{KM} - \widehat{d}_2) \xrightarrow{p} b_1 \theta$$

- Can be estimated with SUR and obtain standard errors easily

## 2. ESTIMATING LOAN-LEVEL RESPONSE TO PARTICULAR SUPPLY SHIFTER

- For Loan-level response to particular shifter  $w_1$ , want to estimate

$$\Delta \log L_{i,j} \approx \text{constant} + \left( b_1 \theta s_j - \frac{b_1}{\rho - 1} s_{-j} \right) w_j + \left( b_1 \theta s_{-j} + \frac{b_1}{\rho - 1} s_{-j} \right) w_{-j} + \Delta \log \tilde{B}_i + v_{i,j} + \tilde{\chi}_{i,j}$$

But have consistent estimator of  $b_1 \theta$ , and KM regression provides a consistent estimator of the scaled EOS,  $-b_1 / (\rho - 1)$ , so to estimate desired loan-level elasticity, calculate:

$$\widehat{b_1 \theta} s_j + \widehat{\beta_{KM}} s_{-j}$$

- Since average loan share is 0.5, average bank-level effect is:

$$0.5 \left( \widehat{b_1 \theta} + \widehat{\beta_{KM}} \right)$$

### 3. ESTIMATING FIRM-LEVEL BORROWING RESPONSE TO ALL SUPPLY SHOCKS

- Recall that impact on total firm-level borrowing stemming from all supply shocks is  $x_{s,i}^* = \theta s_1 \Delta \log a_1 + \theta s_2 \Delta \log a_2$
- The bank fixed effect,  $\zeta_j$ , corresponds to  $-\frac{1}{\rho-1} \Delta \log a_j$ : **off by a scaling factor of  $-\theta(\rho-1)$**
- Recalling that  $\beta_{KM} = -\frac{b_1}{\rho-1}$  we have that  $\frac{b_1\theta}{\beta_{KM}} = -\theta(\rho-1)$ , so:

$$\theta \Delta \log a_j = \underbrace{-\frac{1}{(\rho-1)} \Delta \log a_j}_{\zeta_j} \frac{b_1\theta}{\beta_{KM}},$$

and we know how to estimate all of these objects!

- Then, for each firm, calculate share-weighted average:  $\theta s_1 \Delta \log a_1 + \theta s_2 \Delta \log a_2$
- Obtain the loan-level response to total supply shocks by combining  $\theta \Delta \log a_j$  with  $\beta_{KM}$

# APPLICATIONS USING TOTAL SUPPLY SHOCKS

## Real Effect Regressions

- Recall: running regression of firm outcomes on  $\bar{\zeta}_i = s_{1,i}\zeta_1 + s_{2,i}\zeta_2$ , controlling for the firm FE  $\phi_i$  yields biased estimates for supply effects
- Given that we have now  $x_{s,i}^* = \theta s_1 \Delta \log a_1 + \theta s_2 \Delta \log a_2$ , easy to recover  $x_{d,i}^* = \Delta \log \hat{B}_i$
- Can run firm outcomes on the estimated  $x_{s,i}^*$  and  $x_{d,i}^*$  to obtain consistent estimates for the supply effects!

# APPLICATIONS USING TOTAL SUPPLY SHOCKS

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- Can run firm outcomes on the estimated  $x_{s,i}^*$  and  $x_{d,i}^*$  to obtain consistent estimates for the supply effects!

## Decomposing Aggregate Lending to Demand and Supply

- Can decompose the average change bank  $j$ 's loans in the following manner:

$$\bar{D}_j = \underbrace{\sum_{i \in I_j} q_{ij} x_{s,i,j}^*}_{\text{Own Supply}} + \underbrace{\sum_{i \in I_j} q_{ij} x_{s,i,-j}^*}_{\text{Peer Supply}} + \underbrace{\sum_{i \in I_j} q_{ij} x_{d,i}^*}_{\text{Demand}}$$

- Can apply also to average loan growth in the economy

# PLAN FOR THIS TALK

- 1 A SIMPLE MODEL: FOUR OBJECTS OF INTEREST
- 2 FROM MODEL TO ECONOMETRIC FRAMEWORK
- 3 CURRENT ESTIMATORS THROUGH THE LENS OF THE MODEL
  - KM
  - AW
- 4 ESTIMATING THE FOUR OBJECTS OF INTEREST
- 5 **IMPLEMENTATION WITH SPANISH CRISIS**

# SPANISH DEBT CRISIS 2011

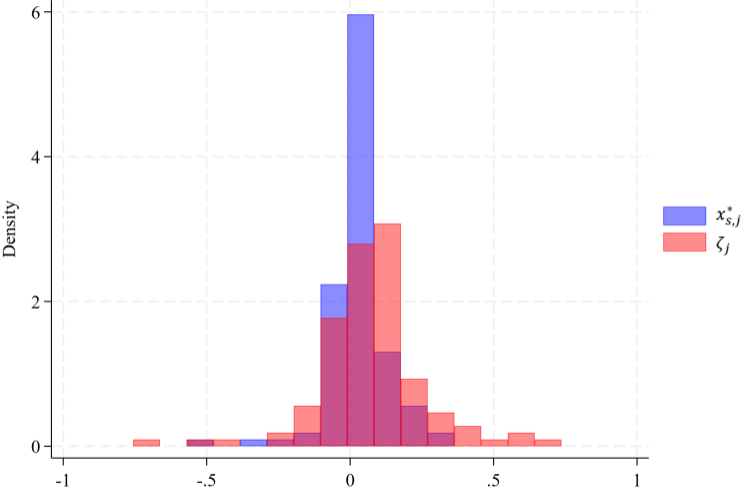
- Analyze loan supply shock stemming from real estate collapse in Spain, 2011-2012
- Specific loan supply shifter: pre-crisis real estate exposure of banks.
- Analyze impact of loan supply shifter and of total supply shock
- Examine real effects using corrected supply shocks, rather than bank fixed effects

## THE IMPACT OF REAL-ESTATE EXPOSURE

	Interpretation	Estimate (s.e)
$\beta_{KM}$	Substitution effect ( $-\frac{b_1}{\rho-1}$ )	-0.183 (0.020)
$d_1$	Biased scale effect	-0.039 (0.019)
$d_2$	Biased (negative of) substitution effect	-0.178 (0.020)
Implied elasticities		
$b_1\theta$	Firm-level effect on total lending	-0.051 (0.032)
$0.5\left(b_1\theta - \frac{b_1}{\rho-1}\right)$	Average loan-level effect on total lending	-0.116 (0.019)

- Estimated  $\beta_{KM}$  much larger than loan-level effect
- Firm-level effect close to zero

# TOTAL SUPPLY EFFECTS VS. BANK FE



## THE IMPACT OF TOTAL SUPPLY SHOCKS ON INVESTMENT

	Long Term Assets Growth	
	(1)	(2)
	Bank FE ( $\bar{\zeta}_i$ )	Supply Shock ( $x_{s,i}^*$ )
Total Supply Shock $\times 100$	0.858	0.410
(s.e.)	(0.162)	(0.161)
Observations	29,939	

- Estimated effect is halved with corrected loan-supply and loan-demand measures, rather than bank and firm FEs.

# THE IMPACT OF TOTAL SUPPLY SHOCKS ON EMPLOYMENT AND VA

	Employment Growth		Value Added Growth	
	(1)	(2)	(3)	(4)
	Bank FE ( $\bar{\zeta}_i$ )	Supply Shock ( $x_{s,i}^*$ )	Bank FE ( $\bar{\zeta}_i$ )	Supply Shock ( $x_{s,i}^*$ )
Total Supply Shock $\times 100$	0.149	-0.097	1.024	0.784
(s.e.)	(0.230)	(0.231)	(0.341)	(0.340)
Observations	26,472		26,837	

- Similar message with employment and value-added regressions

# CONCLUSION

- Use micro-founded theoretical framework with standard ingredients to discipline empirical analysis and derive the four objects of interest
- Show that current empirical methods do not estimate any of the target objects:
  - KM estimator is an elasticity of substitution
  - Bank fixed effects capture supply-side effects, but incorrectly scaled (by the elasticity of substitution)
  - Firm fixed effects capture demand-side effects but also supply-side effects
- Show how to estimate all four objects of interest
- Apply our estimators to Spanish Debt Crisis 2011