Firm Aggregation

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UCSD, Spring 2022

Outline

Outline

MANY POSSIBILITIES

- Look at researchers you admire/know
- They look at the same question from different perspectives
- Evaluate evidence using a model / Evaluate a model using evidence
- Personally, I need to write things down understand them
- So I usually have model' in my work
- Advice: Make notes, like lecture notes. You can avoid reinventing the wheel over and over again.
- Don't derive the same Phillips curve 47 times in your career, have the notes somewhere.

Goal

Interested in estimating the effects of credit supply shocks

- If credit becomes scarce
- Or more expensive
- What happens to real economic activity?
- Difficult to answer in the time series: severe reverse causality concerns
- Bernanke 1983 is a fantastic read

Illustration

- Imagine a firm that “needs financing”
- Firms must finance expenditures in advance

$$TC_j = WN_jR_j$$

- Total Loans L_j

$$L_j = WN_j$$

- Assume the firm uses only labor

$$Y_j = A_jN_j$$

- So the firm marginal cost is

$$MC_j = \frac{WR_j}{A_j}$$

ILLUSTRATION

- Assume firms are monopolistic competitors

$$P_j = \frac{\eta}{\eta - 1} MC_j$$

- And face a demand curve

$$Y_j = Y P_j^{-\eta}$$

- Yielding

$$Y_j = Y \left(\frac{\eta}{\eta - 1} \frac{W R_j}{A_j} \right)^{-\eta}$$

- Or in logs

$$\log Y_j = -\eta \log R_j + \eta \log A_j - \eta \log(\mu) + \log Y - \eta \log W$$

Illustration

$$\log Y_j = -\eta \log R_j + \eta \log A_j - \eta \log(\mu) + \log Y - \eta \log W$$

- Take temporal differences

$$\Delta \log Y_j = -\eta \Delta \log R_j + \eta \Delta \log A_j + \Delta \log Y - \eta \Delta \log W$$

- Assume that there are there are N banks. Firms use only 1 (so R_j is the R of the bank firm j uses).

- Run a simple regression (do not observe A)

$$\Delta \log Y_j = \beta_0 + \beta_1 \Delta \log R_j + \varepsilon_j$$

Illustration

$$\Delta \log Y_j = \beta_0 + \beta_1 \Delta \log R_j + \varepsilon_j$$

What could be wrong?

- Remember our identifying assumption

$$\mathbb{E}(\Delta \log R_j \Delta \log A_j) = 0$$

- In words: Shocks to banks are uncorrelated to the shocks of firms a bank lends to.
- Things you are worried
  - Reverse causality: Credit demand shocks: shock to the oil sector. Oil companies suffer. They reduce their borrowing from The First Oil Bank of America.
  - OVB I: A bank that lends to firms in construction, also holds mortgages in their assets. Housing bubble bursts.
  - OVB II : Local bank lends to local firms. There is a local demand shock. Banks deposits suffer. Firm demand suffers.

Illustration

Solution: Firm assignment as good as random.

- Easier said that done

Illustration

- It is useful to think on a 2 x 2 dif-in-dif.
- Two banks, G or B. $\bar{X}_i$ is the average of X for firms that have bank i

$$\Delta \log \bar{Y}_B - \Delta \log \bar{Y}_G = -\eta \left(\Delta \log R_B - \Delta \log R_G\right) + \eta \left(\Delta \log \bar{A}_B - \Delta \log \bar{A}_G\right.$$

- Covariance of ΔA and ΔR will dictate extent of bias
- Aggregate variables drop out(soaked up in β_0. Missing intercept)
- Elasticity being η the result of many assumptions
- In general, η is not the aggregate effect

Outline

Khwaja and Mian 2008

- Context: Nuclear tests in Pakistan in 1998
- Government stopped USD deposit convertibility
- Note: Not unusual. The American banking system suspended convertibility several times in the XIX and early XX century
- The key references on bank runs and suspension of convertibility are
    - Bryant 1980
    - Diamond Dybvig 1983
    - Gorton 1985

Khwaja and Mian 2008

- USD deposits widely popular
- But heterogeneous across banks. Not random.
- Firms deposited dollars in a commercial bank. Commercial banks sent the dollars to the CB in exchange for rupees. When a depositor demanded their deposits back, the CB handed the dollars to the commercial bank at the *time of deposit* exchange rate.
- Government allowed demand deposits back at the current (worse) exchange rate
- Partial default on dollar deposits
- Savers lost confidence and demanded their deposits back. Differential liquidity shock to the banks

Khwaja and Mian 2008

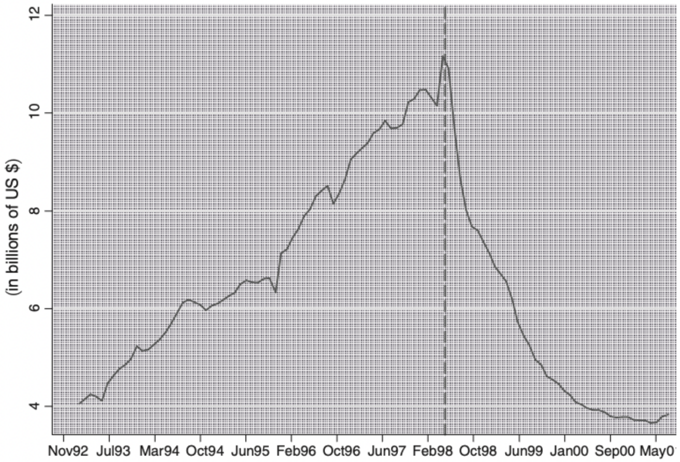


Figure 1. Total Dollar Deposits

Notes: Figure 1 examines the prevalence of foreign currency deposit accounts in Pakistan. These accounts (introduced in the early 1990s) grew steadily until March 1998, the date of the nuclear shock (indicated by the dashed line), and then fell rapidly after that.

KHWAJA AND MIAN 2008

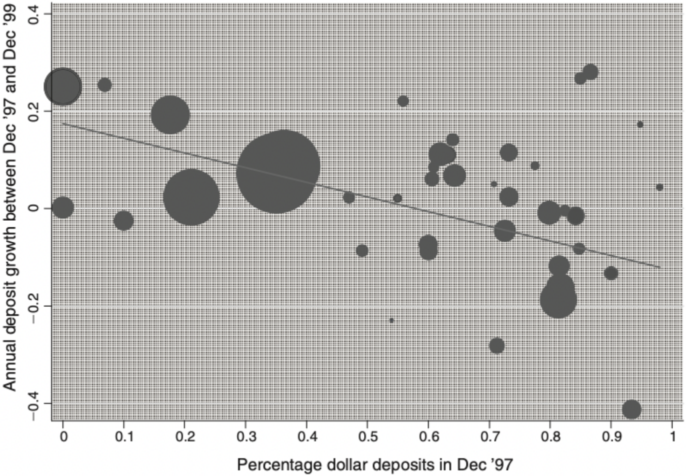


FIGURE 2. ANNUAL DEPOSIT GROWTH IN DEPOSITS AGAINST INITIAL DOLLAR DEPOSIT EXPOSURE (WEIGHTED)

Empirical Specification

$$\Delta L_{ij} = \beta_j + \beta_1 \Delta D_i + \varepsilon_{ij}$$

- L_{ij} loan size of a firm-bank pair
- β_j firm fixed effect
- ΔD_i change in bank-level dollar-denominated deposits
- This firm-fixed effect approach became the standard in the literature

Empirical Specification

- Effectively uses only multi-bank firms
- The firm fixed effect soaks any shock that causes changes in overall firm credit
- How much firms increase their borrowing from one bank relative to another bank
- What could go wrong?

The null hypothesis

$$\Delta L_{ij} = \beta_j + \beta_1 \Delta D_i + \varepsilon_{ij}$$

- What is the economic meaning of the null hypothesis $H_0 : \beta_1 = 0$?

- Think of two worlds in which $\beta_1 = 0$. Thoughts?

Identifying assumption

- Recall

$$\Delta L_{ij} = \beta_j + \beta_1 \Delta D_i + \varepsilon_{ij}$$

- What we need to assume

$$\mathbb{E}(\Delta D_i \varepsilon_{ij}) = 0$$

- What does it mean?

- Construct a scenario that breaks the assumption

RESULTS

TABLE 3—THE BANK LENDING CHANNEL—INTENSIVE MARGIN

	Δ Log loan size						
Dependent variable	FE (1)	FE (2)	FE (3)	OLS (4)	OLS (5)	OLS (6)	OLS (7)
Δ Log bank liquidity	0.60	0.63	0.64	0.46	0.64	0.30	0.33
	(0.09)	(0.10)	(0.11)	(0.14)	(0.17)	(0.12)	(0.15)
Δ Log bank liquidity × small firms						0.57	0.40
						(0.26)	(0.21)
Small firms						0.18	0.24
						(0.06)	(0.03)
Lag Δ log bank liquidity		0.15					−0.13
		(0.10)					(0.14)
Preshock average bank ROA		0.99					−0.27
		(1.73)					(1.66)
Log bank size		0.02					−0.02
		(0.03)					(0.03)
Preshock bank capitalization		−1.16					0.09
		(0.97)					(1.13)
Preshock bank default rate		−0.869					−0.518
		(0.36)					(0.32)
Government bank dummy		0.13					−0.01
		(0.06)					(0.08)
Foreign bank dummy		0.01					−0.12
		(0.06)					(0.08)
Fixed effects	Firm	Firm	Firm × loan-type				Firm Controls
Constant	—	—	—	−0.06	−0.04	−0.14	—
				(0.04)	(0.04)	(0.03)	
Number of observations	5,382	5,382	5,382	5,382	22,176	22,176	22,176
R-squared	0.44	0.44	0.6	0.01	0.02	0.03	0.05

Notes: These regressions examine the bank lending channel for the set of firms borrowing at the time of the shock (the intensive margin) in more detail. All quarterly data for a given loan are collapsed to a single pre– and post–nuclear test period. The nuclear test occurred in the second quarter of 1998, so all observations from 1996:III to 1998:I for a given loan are time-averaged into one. Similarly, all observations from 1998:III to 2000:I are time-averaged into one. Data are restricted to: (a) banks that take retail (commercial) deposits (78 percent of all formal financing), and (b) loans that were not in default in the first quarter of 1998 (i.e., just before the nuclear tests). Columns 1–4 are run on the sample of firms that borrow from multiple banks (preshock) and include firm fixed effects (firm interacted with loan type for column 4). Columns 5–7 also include firms borrowing from single banks and run an OLS specification. Firm controls in column 7 include dummies for each of the 134 cities/towns the firm is located in, 21 industry dummies, whether the firm is politically connected, its membership in a business conglomerate, and whether it borrows from multiple banks. Standard errors in parentheses are clustered at the bank level (42 banks in total).

RESULTS

TABLE 4—THE BANK LENDING CHANNEL—EXTENSIVE MARGIN

Dependent variable	Exit?			Entry?		
	FE (1)	FE (2)	OLS (3)	FE (4)	FE (5)	OLS (6)
Δ Log bank liquidity	−0.21	−0.19	−0.16	0.12	0.15	0.087
	(0.05)	(0.05)	(0.059)	(0.05)	(0.04)	(0.049)
Small			0.084			0.2
			(0.019)			(0.015)
Small × Δ log bank liquidity			0.077			0.11
			(0.084)			(0.067)
Constant	—	—	—	—	—	—
Firm fixed effects	Yes	Yes		Yes	Yes	
Bank controls		Yes	Yes		Yes	Yes
Firm controls			Yes			Yes
Number of observations	6,517	6,517	26,730	8,516	8,516	35,921
R-squared	0.48	0.49	0.09	0.54	0.55	0.21

Notes: These regressions examine how the bank lending channel affected exit and entry of firms (from borrowing). Data are restricted to: (a) banks that take retail (commercial) deposits (78 percent of all formal financing), and (b) loans that were not in default in the first quarter of 1998 (i.e., just before the nuclear tests). Columns 1–3 look at exit by including all loans that were outstanding at the time of the nuclear tests. For a given loan, "exit" is classified as one if the loan is not renewed and the firm exits its banking relationship by the first postshock year. Columns 1–2 further limit the sample to only firms that were borrowing from multiple banks before the shock and include firm fixed effects. Columns 4–6 look at entry and include all loans given out after the nuclear tests quarter. For a given loan, "entry" is classified as one if the loan was made for the first time in the postshock year. Columns 4–5 further limit the sample to only firms that were borrowing from multiple banks after the shock and include firm fixed effects. All regressions include bank level controls: lagged change in bank liquidity, preshock bank ROA, log bank size, bank capitalization, fraction of portfolio in default, and dummies for foreign and government banks. The OLS regressions also include an extensive set of firm-level controls that include dummies for each of the 134 cities/towns the firm is located in, 21 industry dummies, whether the firm is politically connected, its membership in a business conglomerate, and whether it borrows from multiple banks. Standard errors in parentheses are clustered at the bank level (42 banks in total).

Outline

Motivation

- Khwaja-Mian (2008) mostly about financial variables
- In particular credit demand
- Need variation within the firm
- But are credit effects relevant at the firm level?
- Aggregate bank-firm results at the firm level

Ideal Regressor

- Ideally, you would like the cost of capital of the bank
- Difficult (impossible?) to observe
- Uses an exposure measure instead
- $L_{b,j,t}$ The loans given by bank b to firm j in period t
- Change in bank credit

$$\Delta L_{-i,b} = \frac{\sum_{i \neq j} \alpha_{b,j,crisis} L_{b,j,crisis}}{\sum_{i \neq j} \alpha_{b,j,normal} L_{b,j,normal}}$$

- Exposure measure

$$\Delta \tilde{L}_{i,s} = \sum_{b \in s} \alpha_{b,i,last} \Delta L_{-i,b}$$

- Shift-share. Bank-level shocks, firm-level exposure
- Exogenous shifts? Exogenous shares?

Firm-bank relationships are sticky

TABLE I
Banking Relationship Regressions

	(1)	(2)	(3)	(4)
	Lender chosen as lead		Lender chosen as participant	
Explanatory variables				
Previous lead	0.71**	0.67**	0.022**	-0.023**
	(0.011)	(0.012)	(0.0040)	(0.0045)
Previous participant	0.029**	0.020**	0.50**	0.46**
	(0.0014)	(0.0015)	(0.011)	(0.011)
Previous lead × Public (Unrated)	−0.052**	−0.043*		
	(0.016)	(0.017)		
Previous lead × Public (Rated)	−0.058**	−0.086**		
	(0.014)	(0.016)		
Previous participant × Public (Unrated)			0.039*	0.033+
			(0.018)	(0.018)
Previous participant × Public (Rated)			0.012	−0.038*
			(0.014)	(0.015)
Lender FE	Yes	Yes	Yes	Yes
2-digit SIC × lender FE	No	Yes	No	Yes
State × lender FE	No	Yes	No	Yes
Year × lender FE	No	Yes	No	Yes
Public/private × lender FE	No	Yes	No	Yes
All in drawn quartile × lender FE	No	Yes	No	Yes
Sales quartile × lender FE	No	Yes	No	Yes
R^2	0.480	0.504	0.285	0.334
Borrower clusters	3,253	3,253	3,253	3,253
Observations	349,008	349,008	349,008	349,008

Notes. The dependent variable is an indicator for whether the lender serves in the role indicated in the table header. For each loan in which the borrower has previous accessed the syndicated market, the data set contains one observation for each potential lender, where a potential lender is a lender active in the syndicated loan market in that year. The variables Previous lead and Previous participant equal 1 if the lender served as the lead or as a participant on the borrower's previous loan, respectively. The sample covers 2001 to June 2009 and excludes loans to borrowers in finance, insurance, or real estate, and for which the purpose of the loan is not working capital or general corporate purposes. Estimation is via OLS. Standard errors in parentheses and clustered by borrower. +, *, and ** indicate significance at the 0.1, 0.05, and 0.01 levels, respectively.

IV First Stage

TABLE III

Determinants of Bank Lending

	(1)	(2)	(3)
	Change in lending during the crisis		
Explanatory variables			
Lehman cosyndication exposure	−0.14**		
	(0.049)		
ABX exposure		−0.11*	
		(0.041)	
2007–8 trading revenue/assets			0.046
			(0.040)
Real estate charge-offs flag			0.012
			(0.050)
2007–8 real estate net charge-offs/assets			−0.092+
			(0.051)
2007 Bank Deposits/Assets			0.19**
			(0.059)
Joint test p-value	0.008	0.013	0.002
R^2	0.16	0.15	0.35
Observations	42	40	42

Notes. The dependent variable is the change in the annualized number of loans made by the bank between the periods October 2005 to June 2007 and October 2008 to June 2009, with each loan scaled by the importance of the lender in the loan syndicate as described in Section IV.C of the text. Observations weighted by number of precrisis borrowers. The explanatory variables have been normalized to have unit variance. +, *, and ** indicate significance at the 0.1, 0.05, and 0.01 levels, respectively.

Results on Rates

TABLE VII

THE EFFECT OF BANK HEALTH ON INTEREST RATE SPREADS

	(1)	(2)	(3)	(4)	(5)	(6)
	Change in interest rate spread					
	OLS		$\Delta\tilde{L}_{i,s}$ instrumented using			
			Lehman exposure	ABX exposure	Bank statement items	All
Explanatory variables						
%Δ loans to other firms ($\Delta\tilde{L}_{i,s}$)	−14.6**	−12.2**	−23.1*	−20.0	−17.2*	−17.6**
	(5.26)	(4.15)	(11.2)	(13.3)	(7.63)	(6.68)
1-digit SIC, loan year FE	No	Yes	Yes	Yes	Yes	Yes
Bond access/public/private FE	No	Yes	Yes	Yes	Yes	Yes
Additional Dealscan controls	No	Yes	Yes	Yes	Yes	Yes
First stage F-statistic			60.5	7.8	14.3	14.5
J-statistic p-value	.	.	.	.	.	0.967
$E[\Delta Spread]$	130.6	130.6	130.6	130.7	130.6	130.7
$E[\widehat{Spread}{:}\Delta\tilde{L}_{p_{90}} - \Delta\tilde{L}_{p_{10}}]$	−39.7	−33.0	−62.8	−54.3	−46.6	−47.7
Lead lender 1 clusters	34	34	34	32	34	32
Lead lender 2 clusters	30	30	30	28	30	28
Observations	350	350	350	346	350	346

Notes. The dependent variable is the interest spread, in basis points, charged to a firm on a loan starting between October 2008 and June 2009, less the interest spread charged to the same firm on its last loan of the same type (credit line or term loan) obtained prior to September 15, 2008. The regressions exclude loan pairs with an increase of >400 basis points. See the text for further details of the sample construction. The variable $\Delta\tilde{L}_{i,s}$ equals the change in the annualized number of loans made by the bank between the periods October 2005 to June 2007 and October 2008 to June 2009 and has been normalized to have unit variance. The variable Lehman cosyndication exposure equals the fraction of the bank's syndication portfolio where Lehman Brothers had a lead role in the loan deal. The variable ABX exposure equals the loading of the bank's stock return on the ABX AAA 2006-H1 index between October 2007 and December 2007. The balance sheet and income statement items include the ratio of deposits to assets at the end of 2007, the ratio of trading revenue over 2007–8 to assets, the ratio of net real estate charge-offs over 2007–8 to assets, and an indicator for reporting real estate charge-offs. For each firm, the bank-level measures are averaged over the members of the firm's last precrisis loan syndicate, with weights given according to each bank's role. Additional Dealscan controls: multiple lead lenders indicator, loan due during crisis indicator, credit line indicator, log sales at close, all in drawn spread, credit line * all in drawn. Standard errors in parentheses and two-way clustered on the lead lenders in the borrower's last precrisis loan syndicate. +, *, and ** indicate significance at the 0.1, 0.05, and 0.01 levels, respectively.

Results on Employment

TABLE IX

The Effect of Lender Credit Supply on Employment

	(1)	(2)	(3)	(4)	(5)	(6)
	Employment growth rate 2008:3–2009:3					
	OLS		$\Delta\tilde{L}_{i,s}$ instrumented using			
			Lehman exposure	ABX exposure	Bank statement items	All
Explanatory variables						
%Δ loans to other firms ($\Delta\tilde{L}_{i,s}$)	1.17*	1.67**	2.49*	3.17*	2.13*	2.38**
	(0.58)	(0.61)	(1.00)	(1.35)	(0.88)	(0.77)
Lagged employment growth		0.0033	0.0039	0.0045	0.0036	0.0039
		(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
Emp. change in firm's county		0.89*	0.85+	0.86+	0.87+	0.89+
		(0.43)	(0.46)	(0.48)	(0.45)	(0.46)
2-digit SIC, state, loan year FE	No	Yes	Yes	Yes	Yes	Yes
Firm size bin FE	No	Yes	Yes	Yes	Yes	Yes
Firm age bin FE	No	Yes	Yes	Yes	Yes	Yes
Bond access/public/private FE	No	Yes	Yes	Yes	Yes	Yes
Additional Dealscan controls	No	Yes	Yes	Yes	Yes	Yes
First-stage F-statistic			15.5	8.5	18.5	23.1
J-statistic p-value			.	.	.	0.190
$E[g_j^y]$	−0.092	−0.092	−0.092	−0.093	−0.092	−0.093
$E[\hat{g}_j^y : \Delta\tilde{L}_{p_{90}} - \Delta\tilde{L}_{p_{10}}]$	0.027	0.039	0.058	0.074	0.050	0.055
Lead lender 1 clusters	43	43	43	40	43	40
Lead lender 2 clusters	43	43	43	40	43	40
Observations	2,040	2,040	2,040	2,015	2,040	2,015

Notes. The dependent variable is the symmetric growth rate g_j^y of employment. The variable $\Delta\tilde{L}_{i,s}$ equals the change in the annualized number of loans made by the bank between the periods October 2005 to June 2007 and October 2008 to June 2009 and has been normalized to have unit variance. The variable Lehman co-syndication exposure equals the fraction of the bank's syndication portfolio where Lehman Brothers had a lead role in the loan deal. The variable ABX exposure equals the loading of the bank's stock return on the ABX AAA 2006-H1 index between October 2007 and December 2007. The balance sheet and income statement items include the ratio of deposits to assets at the end of 2007, the ratio of trading revenue over 2007–8 to assets, the ratio of net real estate charge-offs over 2007–8 to assets, and an indicator for report real estate charge-offs. For each firm, the bank-level measures are averaged over the members of the firm's last precrisis loan syndicate, with weights given according to each bank's role. In columns (1) and (2) estimation is via OLS. In columns (3)–(6) $\Delta\tilde{L}_{i,s}$ is instrumented using the variable indicated in the column heading. Borrower-level covariates are as of the last precrisis loan taken by each borrower. Firms divided into size bin classes of 1–250, 250–999, and 1,000+, and age bins for birth in the 2000s, 1990s, or earlier. Additional Dealscan controls: multiple lead lenders indicator, loan due during crisis indicator, credit line indicator, log sales at close, all in drawn spread, credit line * all in drawn. Standard errors in parentheses and two-way clustered on the lead lenders in the borrower's last precrisis loan syndicate. +, *, and ** indicate significance at the 0.1, 0.05, and 0.01 levels, respectively.

COUNTERFACTUAL

Outline

Huber 2018

- The allies were convinced that the ability of Germany to wage war came from economic centralization
- From 1948 to 1957, broke up three major banks and created banking zones
- Firms form ties with banks close to them (Degryse and Ongena 2005)
- Commerzbank had three HQ's
- Instrument: Distance to a Commerzbank HQ

RESULTS

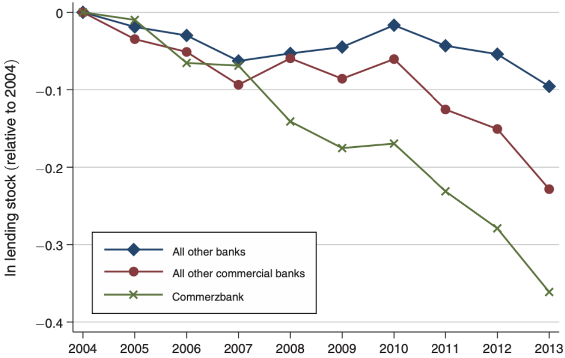


FIGURE 1. THE LENDING STOCK OF GERMAN BANKS

Notes: This figure plots the ln lending stock to German non-financial customers, relative to the year 2004, in 2010 billions of euros. The data for Commerzbank include lending by branches of Commerzbank and Dresdner Bank. I sum their lending stock for the years before the 2009 take-over, using data from the annual reports. For all other banks, I use aggregated data from the Deutsche Bundesbank on German banks and subtract lending by Commerzbank. For all other commercial banks, I subtract lending by Commerzbank, the savings banks, the Landesbanken, and the cooperative banks.

Specification

- Firm-level effects

$$y_{fct} = \zeta + \beta\, CBdep_{fc} \times d_t^{post} + \kappa_c \times d_t^{post} + \Gamma' X_{fc} \times d_t^{post} + \gamma_{cf} + \lambda_t + \varepsilon_{fct}$$

- Thoughts?

Results

TABLE 4—FIRM BANK LOANS AND COMMERZBANK DEPENDENCE

	(1)	(2)	(3)
Firm *CB dep* × *d*	−0.101	−0.166	−0.205
	(0.079)	(0.080)	(0.078)
Observations	12,066	12,066	12,066
R^2	0.009	0.078	0.094
Number of firms	2,011	2,011	2,011
Firm fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
County fixed effects × *d*	No	Yes	Yes
ln age × *d*	No	Yes	Yes
Size bin fixed effects × *d*	No	Yes	Yes
Industry fixed effects × *d*	No	No	Yes
Import and export share × *d*	No	No	Yes

Notes: This table reports estimates from firm OLS panel regressions. The outcome in all columns is firm ln bank loans. Firm *CB dep* is the fraction of the firm's relationship banks that were Commerzbank branches in 2006. *d* is a dummy for the years following the lending cut, 2009 to 2012. The following time-invariant control variables are calculated for the year 2006 and interacted with *d*: fixed effects for 70 industries, 357 counties, and 4 firm size bins (1–49, 50–249, 250–999, and over 1,000 employees); the ln of firm age; the export share (fraction of exports out of total revenue); and the import share (fraction of imports out of total costs). The data include the years 2007 to 2012. R^2 is the within-firm R^2. Standard errors are two-way clustered at the level of the county and the industry.

RESULTS

TABLE 6—FIRM EMPLOYMENT AND COMMERZBANK DEPENDENCE

	(1)	(2)	(3)	(4)	(5)
Firm *CB dep* $\times$ *d*	−0.044	−0.047	−0.053		
	(0.021)	(0.016)	(0.015)		
Low bank debt dep. $\times$ firm *CB dep* $\times$ *d*				−0.035	
				(0.032)	
High bank debt dep. $\times$ firm *CB dep* $\times$ *d*				−0.071	
				(0.020)	
$(0 < \text{firm } CB\ dep \leq 0.25) \times d$					0.007
					(0.016)
$(0.25 < \text{firm } CB\ dep \leq 0.5) \times d$					−0.017
					(0.008)
$(0.5 < \text{firm } CB\ dep \leq 1) \times d$					−0.065
					(0.018)
Observations	12,066	12,066	12,066	12,066	12,066
R^2	0.026	0.098	0.124	0.125	0.125
Number of firms	2,011	2,011	2,011	2,011	2,011
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
County fixed effects $\times$ *d*	No	Yes	Yes	Yes	Yes
Size bin fixed effects $\times$ *d*	No	Yes	Yes	Yes	Yes
ln age $\times$ *d*	No	Yes	Yes	Yes	Yes
Industry fixed effects $\times$ *d*	No	No	Yes	Yes	Yes
Import and export share $\times$ *d*	No	No	Yes	Yes	Yes

Notes: This table reports estimates from firm OLS panel regressions. The outcome in all columns is firm ln employment. Firms with low (high) bank debt dependence have up to (over) 50 percent of their liabilities with banks. The control variables, the standard error calculations, the years covered by the data, and the definition of R^2 are explained in Table 4.

RESULTS

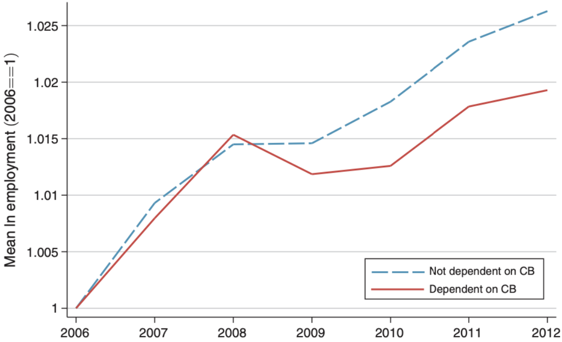


FIGURE 4. FIRM EMPLOYMENT EFFECTS

County Specification

- Aggregate at the county level using average exposure

$$y_{ct} = \zeta + \rho \overline{CBdep_c} \times d_t^{post} + \Gamma' X_c \times d_t^{post} + \gamma_c + \lambda_t + \varepsilon_{fct}$$

Results

Table 9—County outcomes and Commerzbank Dependence (IV)

Outcome:	CB dep	CB dep	GDP	GDP	GDP	Empl	Net migr
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Distance instrument × *d*	0.028	0.042					
	(0.005)	(0.006)					
County *CB dep* × *d*			−0.335	−0.367	−0.345	−0.208	0.026
			(0.118)	(0.182)	(0.173)	(0.113)	(0.020)
Observations	5,005	5,005	5,005	5,005	5,005	5,005	1,925
R^2	0.876	0.941	0.322	0.348	0.355	0.504	0.590
Number of counties	385	385	385	385	385	385	385
County fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Former GDR fixed effects × *d*	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Linear distances × *d*	No	Yes	Yes	Yes	Yes	Yes	Yes
Industry shares × *d*	No	Yes	No	Yes	Yes	Yes	Yes
Export and import shares × *d*	No	Yes	No	Yes	Yes	Yes	Yes
Landesbank in crisis × *d*	No	Yes	No	Yes	Yes	Yes	Yes
Population × *d*	No	Yes	No	No	Yes	No	No
Population density × *d*	No	Yes	No	No	Yes	No	No
GDP per capita × *d*	No	Yes	No	No	Yes	No	No
Debt index × *d*	No	Yes	No	No	Yes	No	No
Estimator	OLS	OLS	IV	IV	IV	IV	IV

Notes: This table reports estimates from county panel regressions. Columns 1 and 2 report the first stage and columns 3 to 7 the IV regressions. The distance instrument is the negative of the county's distance to the closest postwar Commerzbank head office, in 100 kilometers. The linear distances include the county's distances to Düsseldorf, Frankfurt, Hamburg, Berlin, and Dresden. The outcomes, other control variables, weights, standard error calculations, the years covered by the data, and the definition of R^2 are explained in Table 8.

Indirect Effects

- Estimate spillovers in local economies

$$\Delta y_{fc} = \zeta + \beta\, CBdep_{fc} + \sigma\, \overline{CBdep_{fc}} + \Gamma' X_{fc} + \xi\, fc$$

Results

Table 10—The Direct and Indirect Effects on Firm Employment Growth

	(1)	(2)
Firm *CB dep*	−0.030	−0.036
	(0.009)	(0.009)
CB dep of other firms in county	−0.166	−0.170
	(0.076)	(0.082)
Observations	48,101	48,101
R^2	0.012	0.017
Firm controls	Yes	Yes
County controls	No	Yes

Notes: This table reports estimates from cross-sectional firm OLS regressions. The outcome is the symmetric growth rate of firm employment from 2008 to 2012. *CB dep* of other firms in county is the average firm Commerzbank dependence of all the other firms in the county. The firm control variables are the same as in Table 4, except there are no county fixed effects. The county controls and the standard error calculations are the same as in Table 8.

Question

Regional effects in general are not equal to aggregate effects. In this setting what is the main concern to aggregation at the national level?

Outline

Production and Hiring

- Produce by mixing a continuum of intermediates (ω)

$$Y_j = \left(\int_0^1 y_j(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}}$$

- Each intermediate is produced with labor

$$y_j(\omega) = z_j l_j(\omega)$$

Cost minimization problem

Total cost of producing ω

$$TC_j(\omega) = \frac{w_j}{z_j} R_j(\omega) y_j(\omega)$$

Minimize cost s.t. a target quantity Y_j

$$\min_{y_j(\omega)} \int_0^1 TC_j(\omega) d\omega \text{ ; s.t.} Y_j \geq \bar{Y}$$

Standard except for $R_j(\omega)$

More Details

Financing

- $N_{\mathscr{B}}$ bank types, and 1 self-finance option

- For each ω the firm picks the best option

- ε are shifters that reflect the specificity of funding for a given task

$$R_j(\omega) = \min\left\{\frac{R_{\mathscr{S}}}{\varepsilon_{j\mathscr{S}}(\omega)}, \frac{R_1}{\varepsilon_{j1}(\omega)}, \ldots, \frac{R_{N_{\mathscr{B}}}}{\varepsilon_{jN_{\mathscr{B}}}(\omega)}\right\}$$

- Choose one (and only one) financing option for ω

Distribution of shifters

The vector $\boldsymbol{\varepsilon} = \{\varepsilon_{j,1,\mathscr{B}}, ..., \varepsilon_{j,N_{\mathscr{B}},\mathscr{B}}, \varepsilon_{j,N_{\mathscr{B}},\mathscr{B}}, ...\varepsilon_{j,N_{\mathscr{S}},\mathscr{S}}\}$ drawn from a nested Fréchet Distribution

$$F_j(\boldsymbol{\varepsilon}) = \exp\left\{ - \sum_{f \in (\mathscr{B},\mathscr{S})} \bar{\varphi}_f \left(\sum_{b=1}^{N_f} T_{jb} \varepsilon_{fb}^{-\theta} \right)^{\frac{\varphi}{\theta}} \right\}$$

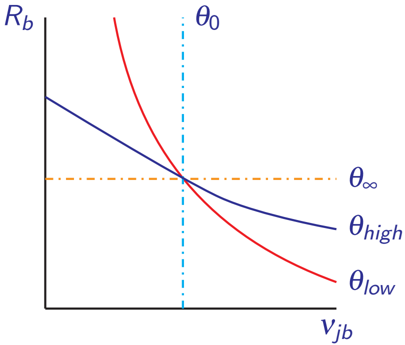
- θ dictates dispersion of shifters across banks
- φ dictates dispersion of shifters across financing type

Allocation of bank borrowing

Firm j borrows from bank b a fraction v_{jb} of its bank-credit needs

$$v_{jb} = \frac{T_{jb} R_b^{-\theta}}{\sum_{k=1}^{N_{\mathscr{B}}} T_{jk} R_k^{-\theta}}$$

$$R_{jB} = \left(\sum_{k=1}^{N_{\mathscr{B}}} T_{jk} R_k^{-\theta} \right)^{-1/\theta}$$



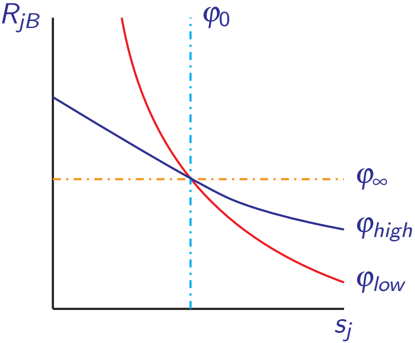
θ is the elasticity of substitution across bank types

Credit Dependence

Firm j finances a fraction s_j of its working capital

$$s_j = \frac{\bar{\varphi} R_{jB}^{-\varphi}}{\bar{\varphi} R_{jB}^{-\varphi} + (1-\bar{\varphi}) R_{jS}^{-\varphi}}$$

$$R_j = \left(\bar{\varphi} R_{jB}^{-\varphi} + (1-\bar{\varphi}) R_{jS}^{-\varphi}\right)^{-1/\varphi}$$



φ is the elasticity of substitution of bank-credit

Households

Representative household maximizes utility

$$U(C,L) = \frac{1}{1-\gamma}\left(C - \frac{L^{\xi+1}}{\xi+1}\right)^{1-\gamma}$$

C is a Dixit-Stiglitz aggregator

$$C = \left(\int_0^1 C_j^{\frac{\eta-1}{\eta}}\, dj\right)^{\frac{\eta}{\eta-1}}$$

L is an aggregator of the labor supplied to different firms

$$L = \left(\int_0^1 L_j^{\frac{1+\alpha}{\alpha}}\, dj\right)^{\frac{\alpha}{1+\alpha}}$$

Subject to

$$C_t = \int_0^1 w_j L_j dj + \int_0^1 \Pi_j dj$$

Experiment 1: Funding shock to all the banks

- Increase banks funding cost from R to Re^u for small u

- Keep the self-financing rate at R

Characterize aggregate output drop up to the second order

Aggregate effects of an across-the-board bank disruption

$$\log Y - \log \bar{Y} \approx -\frac{1}{\xi}\bar{s}\left(u - \varphi(1-\bar{s})\frac{u^2}{2} - \Omega\frac{u^2}{2}\right)$$

Large aggregate response under

1. Elastic labor supply ($1/\xi$ large)

2. Low substitutability of bank credit (φ small)

Experiment 2: increase the lending rate of one bank

- Increase the funding rate of bank b from R to Re^u for small u
- Keep the funding costs of every other bank at R
- Keep self finance rate $R_S = R$

Characterize fall in aggregate output up to a second order

Aggregate effects of a one-bank disruption

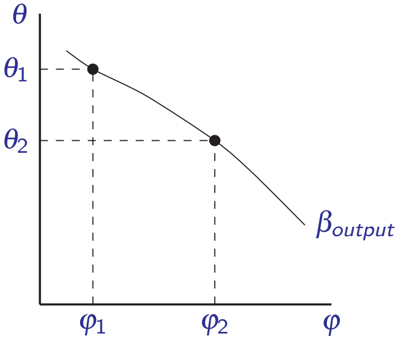
$$\log Y - \log \bar{Y} \approx -\frac{1}{\xi}\bar{s}\left(\nu_b u - \theta\frac{u^2}{2}\Upsilon_1 - \varphi(1-\bar{s})\frac{u^2}{2}\Upsilon_2 - \Omega\Upsilon_2\frac{u^2}{2}\right)$$

Larger effects when

1. Elastic labor supply ($1/\xi$ large)
2. Firms do not substitute across banks (θ small)
3. Firms do not switch away from bank credit (φ small)

Cross-Sectional effects on ouput

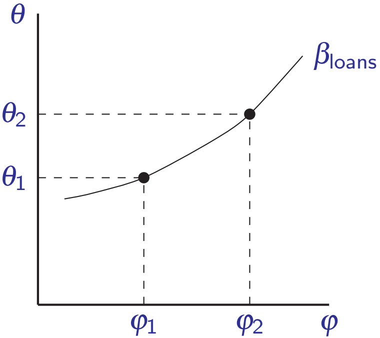
$$\Delta \log \text{Output}_j = \beta_0 + \beta_{\text{output}} T_{jb} + \varepsilon_j$$



$$\beta_{\text{output}} \approx -\frac{\eta \alpha}{\alpha + \eta} \bar{s} u \left(1 - \theta \frac{u}{2} \mathscr{M}_1 - \varphi (1 - \bar{s}) \frac{u}{2} \mathscr{M}_2\right)$$

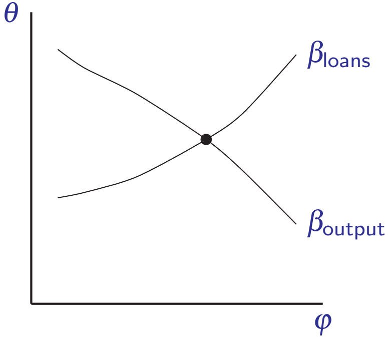
Cross-Sectional effects on credit

$$\Delta \log \text{Loans}_j = \beta_0 + \beta_{\text{loans}} T_{jb} + \varepsilon_j$$



$$\beta_{\text{credit}} \approx \beta_{\text{output}} \frac{\alpha+1}{\alpha} - \varphi(1-s)u\left(1+\varphi\frac{u}{2}s\mathscr{M}_1 - \theta\frac{u}{2}\mathscr{M}_2\right)$$

IDENTIFICATION



Recover θ and φ conditional on knowing α, η

Back

Firm fixed-effect regressions

$$\Delta \log \text{Loans}_{jb} = \beta_j + \beta_{\text{fe}} T_{jb} + \varepsilon_{jb}$$

In the model, the fixed-effect elasticity

$$\beta_{\text{fixed effect}} \approx -\theta u + \theta^2 \frac{u^2}{2} \mathscr{M}_1 \tag{1}$$

Contains no information about φ

Observational equivalence

$$\Delta \log \text{Output}_j = \beta_0 + \beta_{\text{output}} T_{jb} + \varepsilon_j$$

$$\beta_{\text{output}} \approx -\frac{\eta\alpha}{\alpha+\eta}\bar{s}u\left(1-\theta\frac{u}{2}\mathscr{M}_1-\varphi(1-\bar{s})\frac{u}{2}\mathscr{M}_2\right)$$

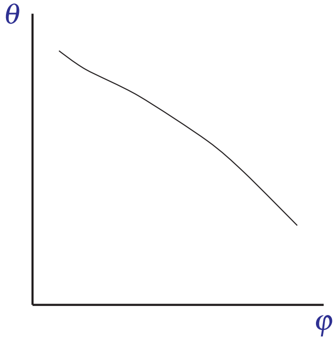
Alternative worlds consistent with small elasticities

1. Firms are elastic in subsituting sources of finance (φ, θ large)
2. Firm-specific labor supply is inelastic (α small)
3. Varieties are not substitutable (η small)

Different assumptions of α, η, change inferred φ, θ

Observational equivalence

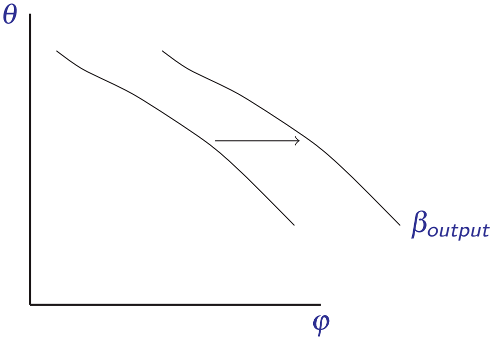
$$\Delta \log \mathsf{Output}_j = \beta_0 + \beta_{\mathsf{output}} T_{jb} + \varepsilon_j$$



$$\beta_{\mathsf{output}} \approx -\frac{\eta\alpha}{\alpha+\eta}\bar{s}u\left(1-\theta\frac{u}{2}\mathscr{M}_1-\varphi(1-\bar{s})\frac{u}{2}\mathscr{M}_2\right)$$

Observational equivalence

$$\Delta \log \text{Output}_j = \beta_0 + \beta_{\text{output}} T_{jb} + \varepsilon_j$$



$$\beta_{\text{output}} \approx -\frac{\eta\alpha}{\alpha+\eta}\bar{s}u\left(1-\theta\frac{u}{2}\mathscr{M}_1-\varphi(1-\bar{s})\frac{u}{2}\mathscr{M}_2\right)$$

Outline of the full model

Banks:

- Pay deposit rates to savers
- Maximize profits by setting lending rates Go there
- Suffer balance sheet shocks: Equity drops

Firm owners

- Heterogeneous in wealth and productivity Go there
- Own one particular firm
- Deposit assets in banks Go there

In continuous time to solve faster

Allocation of deposits

Each entrepreneur allocates a share ω_{bt} of bank deposits to bank b

$$\omega_{bt} = \frac{R_{bd}^{\chi}}{\sum_{\forall k} {R_{kd}}^{\chi}}$$

- When $\chi \to \infty$ then savings are perfectly elastic
- Analogous to the discrete choice block for lending
- Very important. More competition in the banking sector χ large creates macro amplification

Banks' balance sheets

$$\text{Loans}_{bt} = \text{Deposits}_{bt} + \text{Equity}_{bt} \tag{2}$$

Total loans sum up loans to individual firms

$$\text{Loans}_{bt} = \int_0^1 \text{Loans}_{jbt}\, dj = \int_0^1 \text{Expenditure}_{jt} s_{jt} v_{bjt}\, dj \tag{3}$$

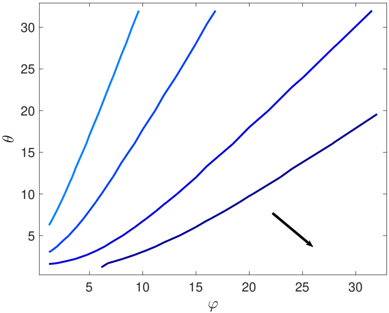
Deposits sum up the deposits that banks get from every entrepreneur

$$\text{Deposits}_{bt} = \int_0^1 \text{Deposits}_{jbt}\, dj \tag{4}$$

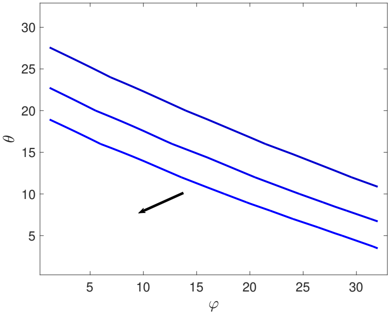
Exogenous Driver Solution Method

Identification argument holds

Elasticity of Credit



Elasticity of Employment



1. Upward sloping locus for credit
2. Downward sloping locus for employment

In the simple model | Sensitivities

Aggregate Bank Shocks

- Shock all the banks' equity at the same time

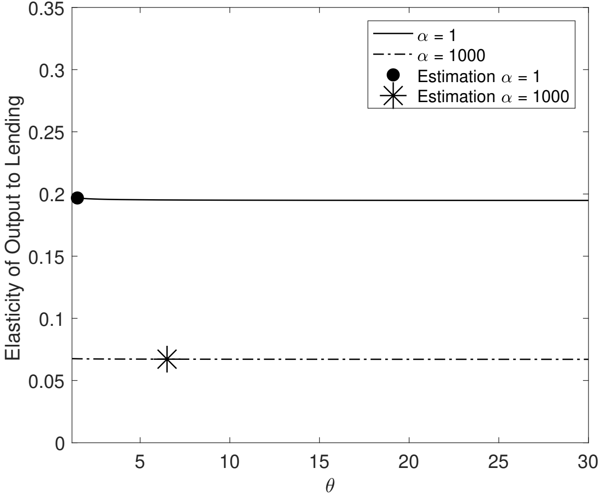
Aggregate elasticity of output to lending

We start by focusing on the elasticity of output to lending

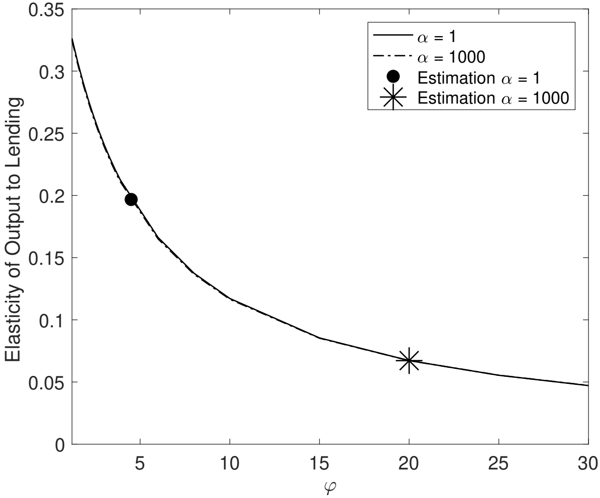
$$\varepsilon^M = \frac{\int_0^\infty e^{-\rho t} \left(\log(Y_t) - \log(\bar{Y})\right) dt}{\int_0^\infty e^{-\rho t} \left(\log(\text{Lending}_t) - \log(\overline{\text{Lending}})\right) dt} \tag{5}$$

- The macroeconomic equivalent of an IV estimate. Ratio of:
  - Reduced Form: Response of output to bank funding
  - First Stage: Response of lending to bank funding
- Intertemporal response adjusting for differences in persistence

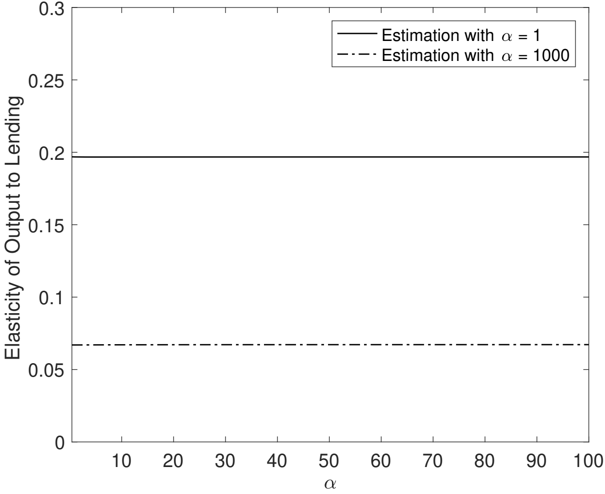
Irrelevance of θ to an aggregate shock



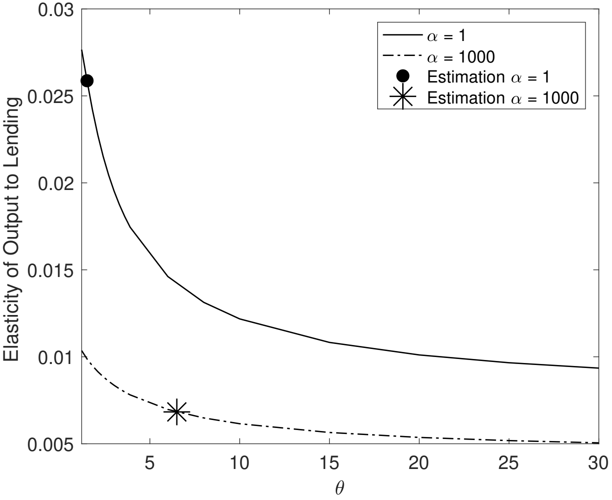
Credit dependence and Output



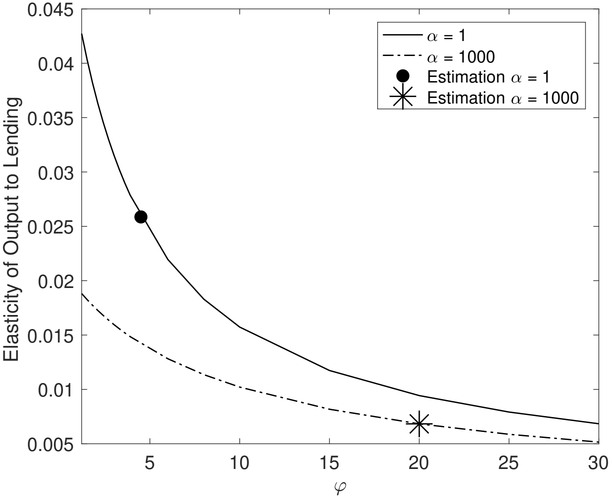
RESULT NOT DRIVEN BY α ITSELF



Irrelevance of θ to an aggregate shock



Credit dependence and Output

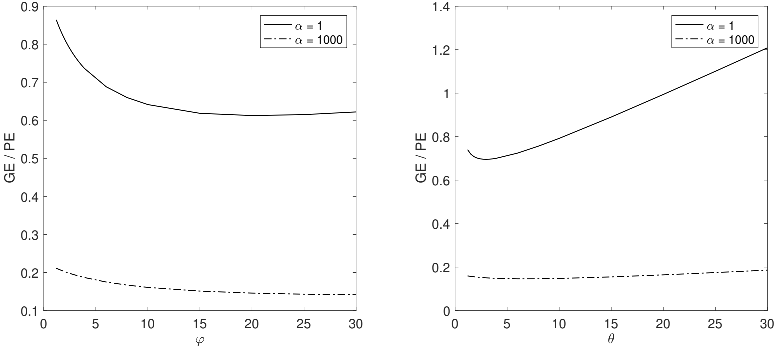


Back-of-the-envelope aggregation

Aggregate the cross-sectional estimates

$$\varepsilon^{cs} = \frac{\int_0^T e^{-\rho t} \int_0^1 (\log(Y_{jt}) - \log(Y_{ct}))\, djdt}{\int_0^T e^{-\rho t} \int_0^1 \log(\text{Lending}_{jt}) - \log(\text{Lending}_{ct}) djdt} \tag{6}$$

GE versus PE effects



Ratio of GE to PE falls in output after a one-bank shock

Conclusions

- Cross-sectional regressions are informative about aggregate shocks
  - Employment growth on pre-existing exposure
  - Credit growth on pre-existing exposure
- Firm fixed-effect regressions informative about idiosyncratic shocks
- Observational equivalence on firm-level regressions
  - GE $\approx$ 70% PE (preferred)
  - GE $\approx$ 20% PE (alternative)

Outline

Motivation

- Cross-sectional effects of having more collateral on firm-investment
- Broad literature of firm excess sensitivity
- What are the TFP and output effects of collateral constraints?

Cross-Sectional Elasticity

$$\frac{i_{it}}{k_{it}} = a + \beta \frac{REValue_{it}}{k_{i,t-1}} + Offprice_{it} + \Gamma' X_{it} + \nu_{it}$$

- Chaney, Sraer, Thesmar (2012) AER paper all about this

- Exogenous shock to real estate value, increases the value of collateral, which increases debt capacity and investment for financially-constraint firms

Production

$$q_{it} = e^{z_{it}} \left(k_{it}^{\alpha} l_{it}^{1-\alpha} \right)$$

- Firm-level productivity AR(1)
- Downward-sloping demand curves

$$q_{it} = Q p_{it}^{-\phi}$$

- Curvature in the revenues minus wage bill

$$\pi(z_{it}, k_{it}) = bQ^{1-\theta} w^{-(1-\alpha)\theta/\alpha} e^{z_{it}\theta/\alpha} k_{it}^{\theta},$$

- For $\theta = \frac{\alpha(\phi-1)}{1+\alpha(\phi-1)}$
- Why is it important?

Capital adjustment frictions

- Law of motion of capital stock

$$k_{it+1} = k_{it} + i_{it} - \delta k_{it}$$

- Convex costs of adjustment

$$\frac{c}{2}\left(\frac{i}{k}\right)^2 k$$

Financial Frictions

- interest rate spread on debt m
- Cost of issuing equity. If cash-flows are x, post-issuance

$$G(x) = x(1 + e1_{x<0})$$

- Collateral constraint

$$(1+r)d_{it+1} \leq s((1-\delta)k_{it+1} + \mathbb{E}(p_{t+1}|p_t) \times h)$$

- s parameterize loose or tight the constraint is
- h is the amount of real estate (common across firms)
- Friction comes from limited enforcement
- h is a parameter

Estimation

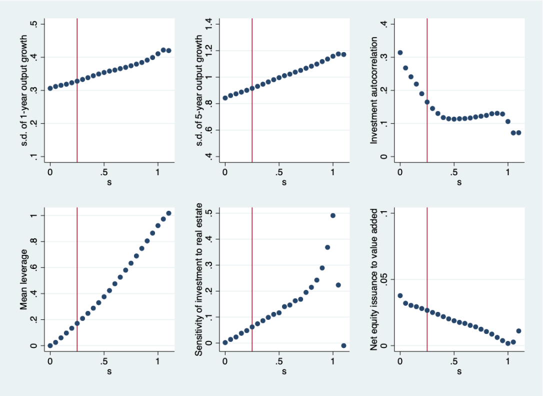
- Autocorrelation of investment rates to infer the adjustment cost c

- This is usual in investment models (see Cooper and Haltiwanger, 2006)

- Use the cross-sectional elasticity β in an SMM to estimate s

- Use data on equity issuances to estimate e

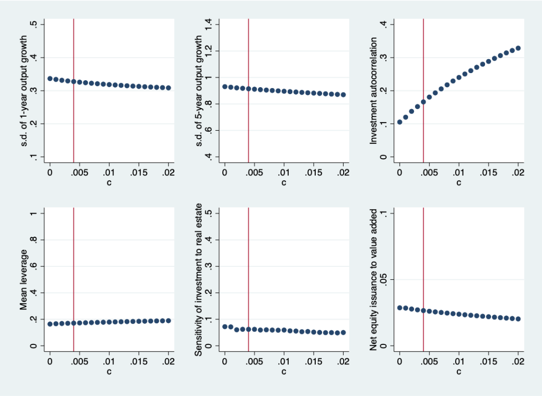
Figure E.1: Sensitivity of moments to pledgeability s



Note: In this figure, we set all estimated parameters (s, c, ρ, σ, H and e) at their SMM estimate in our preferred specification – as per column 3, Panel A in Table 2. We fix w and Q at their reference levels: $w = 0.03$ and $Q = 1$. We then vary s from 0 to 1. For each value of s that we choose, we solve the model, simulate the data, and compute four target moments, plus the average leverage ratio and the sensitivity of debt issuance to real estate value. Each panel corresponds to one moment. The red vertical line corresponds to the SMM estimate of s.

Capital or Financial frictions?

Figure E.2: Sensitivity of moments to adjustment costs c



Note: In this figure, we set all estimated parameters (s, c, ρ, σ, H and e) at their SMM estimate in our preferred specification – as per column 3, Panel A in Table 2. We fix w and Q at their reference levels: $w = 0.03$ and $Q = 1$. We then vary c from 0 to 0.02. For each value of c that we choose, we solve the model, simulate the data, and compute four target moments, plus the average leverage ratio and the sensitivity of debt issuance to real estate value. Each panel corresponds to one moment. The red vertical line corresponds to the SMM estimate of c.

GE Block

- Aggregate production Q is CES

- Resource constraint

$$Q_t = C_t + I_t + AC_t$$

- Quasi linear utility

$$L_t^s = \bar{L} w_t^{\varepsilon}$$

Counterfactual

- Two alternatives of creating the world with no financial constraints

1. $s \to \infty$
2. $e = 0$

- Which is the correct one?

Results

Table 3: **Aggregate Effects of Collateral Constraints**

Specification:	(1) Model 1 $c = 0, e = +\infty$	(2) Model 2 $c > 0, e = +\infty$	(3) Model 3 $c > 0, e > 0$
Panel A: *General equilibrium results*			
Δ log(TFP)	0.031	0.027	0.014
Δ log(Output)	0.151	0.120	0.071
Δ log(wage)	0.101	0.080	0.048
Δ log(L)	0.051	0.040	0.024
Δ log(K)	0.282	0.215	0.137
Panel B: *Partial equilibrium results, holding Q fixed only*			
Δ log(TFP)	0.012	0.012	0.005
Δ log(Output)	0.110	0.088	0.052
Δ log(wage)	0.073	0.059	0.035
Δ log(L)	0.037	0.029	0.017
Δ log(K)	0.240	0.185	0.117
Panel C: *Partial equilibrium results, holding (Q, w) fixed*			
Δ log(TFP)	-0.040	-0.029	-0.020
Δ log(Output)	0.400	0.320	0.189
Δ log(wage)	-	-	-
Δ log(L)	0.400	0.320	0.189
Δ log(K)	0.531	0.417	0.254

Note: This table reports the results of the counterfactual analysis for different SMM parameter estimates. The general equilibrium analysis is described in Section 4 and reported in Panel A. Columns (1)-(3) correspond to the three different models described in Columns (1)-(3) of Table 2: Column (1) assumes no adjustment cost ($c = 0$) and infinite cost of equity issuance ($e = +\infty$). Column (2) allows for adjustment cost but still assumes infinite cost of equity issuance. Column (3) also allows for finite cost of equity issues. Panel B implements the same methodology, except that it holds the aggregate demand shifter Q constant, but the wage w clears the labor market. Panel C holds both the aggregate demand shifter Q and wage w constant. Results in both panels are shown as log deviations from the constrained estimated model to the unconstrained benchmark. The unconstrained benchmark correspond to an equilibrium where firms face the same set of parameters as in the SMM estimate – reported in the same column, Table 2, panel A – but do not face a constraint on equity issuance ($e = 0$). In this unconstrained benchmark, investment reaches first best, but firms still benefit from the debt tax shield. *Reading*: In column 1 (no adjustment cost, no equity issuance), the aggregate TFP loss compared to a benchmark without financing constraints is 3.1%.

Results

- The results depend a lot on the persistence of productivity ρ
- Why?
- Recommended reading: Moll (2014)

Mispecification

- Two alternatives to estimate the model
  - Estimate the structural parameters Θ to target (among others) β
  - Estimate the structural parameters Θ to target (among others) debt to capital ratios
- Which is better?
- Offer one metric: Effects of model mispecification
- Also: Effect of measurement error

Mispecification

- Idea: Complicate the model
  1. Intangible capital
  2. Mismeasured capital
  3. Economic depreciation $\neq$ accounting depreciation
  4. Secured debt
- Estimate the extended and restricted (benchmark) model
- What is the effect on the counterfactuals of TFP and output
- Follows Isaiah, Gentzkow, Shapiro (2017) (which I should study).

MISPECIFICATION

Table 6: Estimation Error and Distance from Correct Specification

Relative error in estimation of:	log TFP loss		log Output loss	
Misspecified SMM targets:	β	Leverage	β	Leverage
	(1)	(2)	(3)	(4)
Misspecification parameters:				
Intangible capital share ($\boldsymbol{I}$)	-.0056	-.41	-.0021	-.39
Unobserved physical capital share ($\boldsymbol{U}$)	-.19	-.34	-.18	-.33
Price measurement error ($\boldsymbol{\sigma_u}$)	.12	-.0033	.11	-.0058
Unobserved debt capacity - need ($\boldsymbol{d_0}$)	.028	1.2	.041	1.2
Fixed unsecured debt ($\boldsymbol{\kappa}$)	.098	-.43	.075	-.42
Actual tax rate - 33% ($\boldsymbol{\tau} - 0.33$)	-.73	-.54	-.68	-.49
Constant	.063	.14	.065	.13
Observations	4,000	4,000	4,000	4,000
R^2	0.32	0.74	0.29	0.73

Note: We simulate datasets from 4,000 alternative models. Each alternative model correspond to the baseline model augmented in six different dimensions described in Section 5.3.3. Six "misspecification" parameters control the degree of departure from the baseline model along these dimensions: $\boldsymbol{\Theta} = (\boldsymbol{\mathcal{I}}, \boldsymbol{U}, \boldsymbol{\sigma_u}, \boldsymbol{d_0}, \boldsymbol{\kappa}, \boldsymbol{\tau})$. We estimate the baseline (misspecified) model on these 4,000 datasets using two separate approaches: one estimation targets leverage; another targets the reduced-form moment β. We then regress:

$$\frac{\hat{X}_i - X_i}{\frac{1}{N}\sum_j X_j} = a + b\frac{\boldsymbol{\mathcal{I}}_i}{\max_j \boldsymbol{\mathcal{I}}_j} + c\frac{\boldsymbol{U}_i}{\max_j \boldsymbol{U}_j} + d\frac{\boldsymbol{\sigma}_{\boldsymbol{u},i}}{\max_j \boldsymbol{\sigma}_{\boldsymbol{u},j}} + e\frac{\boldsymbol{d}_{0,i}}{\max_j \boldsymbol{d}_{0,j}} + f\frac{\boldsymbol{\kappa}_i}{\max_j \boldsymbol{\kappa}_j} + g\frac{\boldsymbol{\tau}_i - 0.33}{\max_j(\boldsymbol{\tau}_j - 0.33)} + \epsilon_i$$

where X stands for the estimated TFP/output losses and i index alternative models. Standard errors are omitted because they are irrelevant in this cross-section of simulations, but the number is large enough to ensure smooth, linear, relationships as shown in Appendix Figures E.7 and E.8. *Reading*: When the fraction of intangible capital increases from 0 to .5 (maximum misspecification), the misspecification bias on TFP losses estimated by targeting leverage increases from zero (correctly specified) to 41% of the average TFP loss in the cross-section.

Outline

HUBER (2022)

- This discussion follows Huber (2022) "Estimating General Equilibrium Spillovers of Large-Scale Shocks"
- Usual method is to aggregate using a model
- Or to generate a sufficient statistic
- Potentially could estimate spillovers directly using experiments or quasi-experiments

Huber (2022)

- There is a treatment that directly affects firms in the treatment
- But also affects firms that belong to the same "group" as treated firms
- Groups can be industries, regions, supply chains,..
- Direct spillover estimation requires exogenous treatment across firms **and** groups

Intuition

- To estimate the spillover the standard practice is to include leave-out means in the regression

$$y_{fg} = \beta_0 + \beta_1 Treatment_{fg} + \beta_2 \overline{Treatment}_g + \varepsilon_{fg}$$

- where $\overline{Treatment}_g = \frac{1}{N-1} \sum_{j \neq f \in g} y_{jg}$

- Two complications in estimating β_2

  1. Multiple types of spillovers

  2. Mismeasured treatment status due to nonlinear effects or measurement error

Intuition

- Imagine a firm f in sector s, that produces in region r, and sells in region d
- Should the right regression be?

$$y_{fs} = \beta_0 + \beta_1 Treatment_{fs} + \beta_2 \overline{Treatment}_s + \varepsilon_{fs}$$

- or

$$y_{fr} = \beta_0 + \beta_1 Treatment_{fr} + \beta_2 \overline{Treatment}_r + \varepsilon_{fr}$$

- or

$$y_{fd} = \beta_0 + \beta_1 Treatment_{fd} + \beta_2 \overline{Treatment}_d + \varepsilon_{fd}$$

- or all of them y_{fsrd} including all the leave-out means?

Setting

- Let's consider the setting in Huber (2022)

$$y_i = \beta x_i + \sum_{j \neq i, r(j)=r(i)} \lambda^j x_j + \sum_{k \neq i, s(k)=s(i)} \gamma^k x_k + \alpha + \varepsilon_i$$

- here x is treatment status. s are sectors, r are regions.

- Treatment is as good as random

$$\mathbb{E}(x_i \varepsilon_i) = 0 \forall i$$

- The biases we are talking about will not arise with assignment or reflection problems

SETTING

$$y_i = \beta x_i + \sum_{j \neq i, r(j)=r(i)} \lambda^j x_j + \sum_{k \neq i, s(k)=s(i)} \lambda^k x_k + \alpha + \varepsilon_i$$

- Assumption: No heterogeneity in spillovers $\lambda^j = \lambda$, and $\gamma^k = \gamma$
- So outcomes are functions of individual treatment, and two "leave-out" means

$$y_i = \beta x_i + \lambda \overline{x}_{r(i)} + \gamma \overline{x}_{s(i)} + \alpha + \varepsilon_i$$

- Treatment status (intensity)

$$x_i = z_i + u_r(i) + u_s(i) + v_i$$

- z_i is observable, uncorrelated within r and s, and will be an instrument for x
- u_r, u_s, z, v are uncorrelated with each other, and with ε

Testing for the wrong spillover

- Imagine the right DGP is

$$y_i = x_i + \overline{x}_{r(i)} + \varepsilon_i$$

- $(\beta = 1,\ \lambda = 1, \gamma = 0)$
- Treatment varies systematically across regions and sectors
- Instead you run the regression

$$y_i = b_1 x_i + b_2 \overline{x}_{s(i)} + \xi_i$$

- $\hat{b}_2 / \hat{b}_1 = -0.33$.
- Why? $\overline{x}_{r(i)}$ enters the error term
- $\overline{x}_{r(i)}$ is correlated with $u_r(i)$, and therefore with x_i
- Biases both $\hat{b}_1$ and $\hat{b}_2$

Solution

- Economic theory!
- Example of Mian and Sufi: regional spillovers should be mostly (only?) important for non-tradeable firms
- Test H_0 of zero regional spillovers among tradeable firms
- Other solution, use $\bar{z}_s$, $\bar{z}_s$ as instruments

Testing for the incorrect spillover

Table I: Testing for the wrong spillover biases estimates

	(1)	(2)	(3)	(4)
Coefficient on x_i	1.626***	0.999***	0.995***	0.998***
(true coefficient = 1)	(0.059)	(0.008)	(0.037)	(0.012)
Coefficient on $\overline{x_{s(i)}}$	-0.530***	0.001	-0.012	0.004
(true coefficient = 0)	(0.051)	(0.009)	(0.127)	(0.033)
Coefficient on $\overline{x_{r(i)}}$		1.000***		
(true coefficient = 1)		(0.009)		
Group-level variation		Systematic		Random
Estimator	OLS	OLS	IV	OLS

Notes: The variable x_i is the direct treatment status of firm i, which is in sector $s(i)$ and region $r(i)$; and $\overline{x_{s(i)}}$ and $\overline{x_{r(i)}}$ are the average treatment status of all other firms in $s(i)$ and $r(i)$, respectively, apart from firm i (leave-out means). The IV specification in column 3 instruments for x_i and $\overline{x_{s(i)}}$ using z_i and $\overline{z_{s(i)}}$. Systematic variation means that $u_{s(i)}$ and $u_{r(i)}$ (from equation 7) are log-normally distributed with mean 0 and standard deviation 1. Random variation indicates that $u_{s(i)}$ and $u_{r(i)}$ are 0 for every firm. The reported coefficients and standard errors are averaged over 100 simulations.

Testing for incomplete spillovers

- Imagine the right DGP is

$$y_i = x_i + \overline{x}_{r(i)} + \overline{x}_{s(i)} \varepsilon_i$$

- $(\beta = 1,\ \lambda = 1, \gamma = 1)$

- Treatment varies systematically across regions and sectors

- Instead you run the regression

$$y_i = b_1 x_i + b_2 \overline{x}_{s(i)} + \xi_i$$

Testing for the incorrect spillover

Table II: Testing for just one type of spillover biases estimates

	(1)	(2)	(3)	(4)
Coefficient on x_i	1.626***	0.995***	0.999***	0.998***
(true coefficient = 1)	(0.059)	(0.037)	(0.008)	(0.012)
Coefficient on $\overline{x_{s(i)}}$	0.470***	0.988***	1.001***	1.004***
(true coefficient = 1)	(0.051)	(0.127)	(0.009)	(0.033)
Coefficient on $\overline{x_{r(i)}}$			1.000***	0.999***
(true coefficient = 1)			(0.009)	(0.009)
Group-level variation		Systematic		Random
Estimator	OLS	IV	OLS	OLS

Notes: The variable x_i is the direct treatment status of firm i, which is in sector $s(i)$ and region $r(i)$; and $\overline{x_{s(i)}}$ and $\overline{x_{r(i)}}$ are the average treatment status of all other firms in $s(i)$ and $r(i)$, respectively, apart from firm i (leave-out means). The IV specification in column 2 instrument for x_i and $\overline{x_{s(i)}}$ using z_i and $\overline{z_{s(i)}}$. Systematic variation means that $u_{s(i)}$ and $u_{r(i)}$ (from equation 7) are log-normally distributed with mean 0 and standard deviation 1. Random variation indicates that $u_{s(i)}$ and $u_{r(i)}$ are 0 for every firm. The reported coefficients and standard errors are averaged over 100 simulations.

Measurement Error

- You observe $x_i^* = x_i + \eta_i$
- η uncorrelated with $\varepsilon, z, u_r, u_s, v$
- The most benign case of measurement error
- In this case $\overline{x}^*_{r(i)} = \overline{x}_{r(i)} + \overline{\eta}_{r(i)}$
- Intuitively, variation caused to x will be attributed to $\overline{x}$
- You should think carefully about measurement error

MEASUREMENT ERROR WITHOUT TRUE SPILLOVERS

Panel A: Specifications with zero true spillover effect

	(1)	(2)	(3)	(4)	(5)
Coefficient on x_i^*	0.999***	0.863***	0.754***	0.469***	1.000***
(true coefficient = 1)	(0.009)	(0.010)	(0.010)	(0.009)	(0.029)
Coefficient on $\overline{x_{r(i)}}^*$	-0.000	0.129***	0.229***	0.474***	0.001
(true coefficient = 0)	(0.011)	(0.012)	(0.013)	(0.019)	(0.103)
Measurement error	None	Low	Medium	High	High
Estimator	OLS	OLS	OLS	OLS	IV

Instrument x and $\bar{x}$ with z and $\bar{z}$.

Measurement Error with True Spillovers

Panel B: Specifications with true spillover effect

	(1)	(2)
Coefficient on x_i^*	0.521	0.700
(true coefficient = 1)	(0.009)	(0.011)
Coefficient on $\overline{x_{r(i)}}^*$	1.365	0.693
(true coefficient = 1)	(0.032)	(0.045)
Measurement error	High	High
Estimator	OLS	OLS
Group-level variation	Systematic	Random

Spillover over or under estimated depending on whether u_r changes across regions. Similar issues in peer-effect literature in labor (Ammermueller and Pischke (2009).