Capital Allocation across Regions, Sectors and Firms

Evidence from a Commodity Boom in Brazil

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Introduction

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  - from agriculture to industry and services
  - from rural to urban areas

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  - Open economies
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- This process has not taken off in several developing economies
- Theoretical literature offers a rich set of explanations
  - Open economies
  - Market failures
- However, direct empirical evidence is extremely scarce

This paper: the finance channel
Theory

Standard Heckscher-Ohlin model

Effects of agricultural productivity growth ($A_a \uparrow$)

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1. Static effect
   - $A_a \uparrow$ generates increase in MPK_a
   - Capital reallocates towards agriculture

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2. Dynamic effect
   - $A_a \uparrow$ generates larger savings and capital accumulation
   - Capital market equilibrium requires an expansion of the K-intensive sector (Rybczynski Theorem, 1955)
   - Capital reallocates towards manufacturing

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$\rightarrow$ Dynamic effect has been overlooked by the development literature

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Empirics

1. Reallocation of capital across sectors: **agriculture** $\rightarrow$ **manufacturing**
   - We exploit a large and exogenous increase in agricultural productivity
   - Legalization of GM soy in Brazil
   - Differential impact on yields in areas with different soil and weather

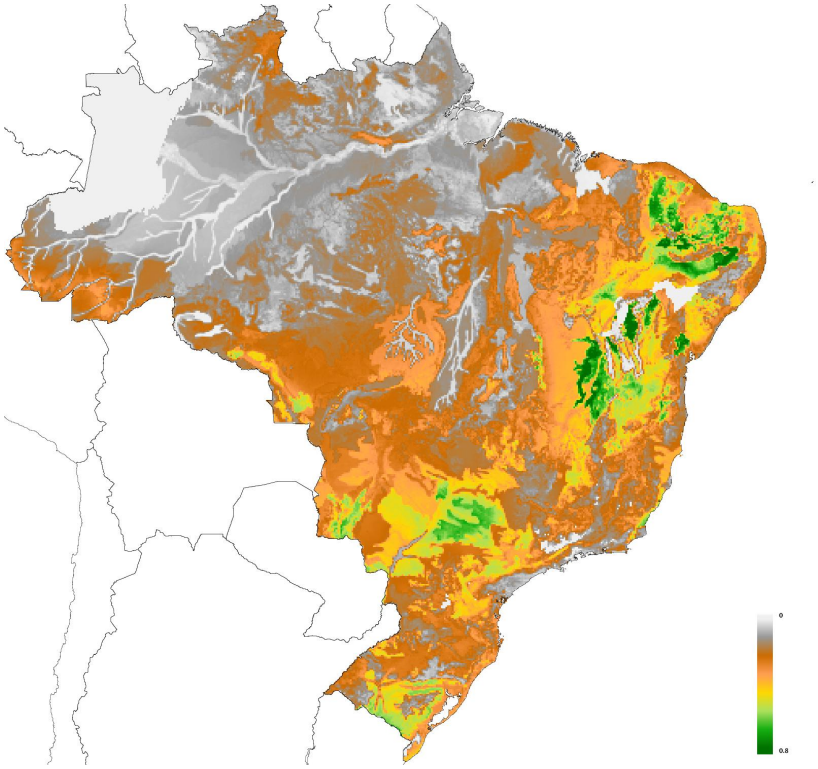
Identification Strategy I

Local effects of agricultural technical change

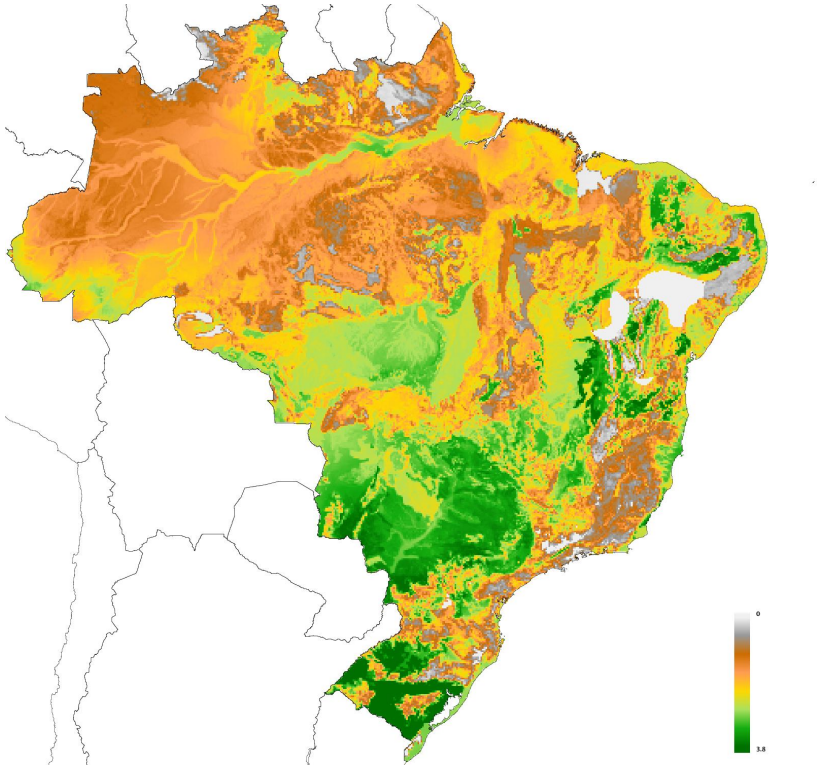
Instrument: measure of exogenous technical change

Outcome: savings deposits in local bank branches

Potential yields traditional soy



Potential yields GM soy



The finance channel
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   - Use detailed branch-level balance sheet data for 115 Brazilian Banks
   - link soy producing regions *(origin)* to non-soy producing regions *(destination)*

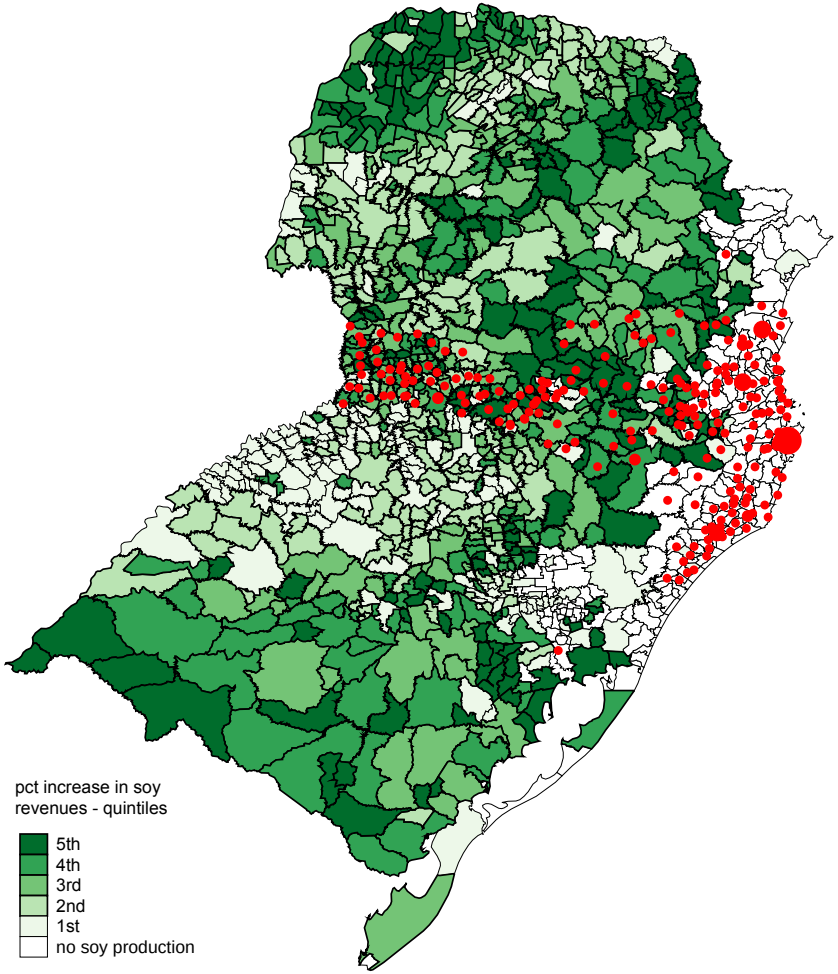
Identification Strategy II

Reallocation across regions

Example: 2 banks and 2 regions

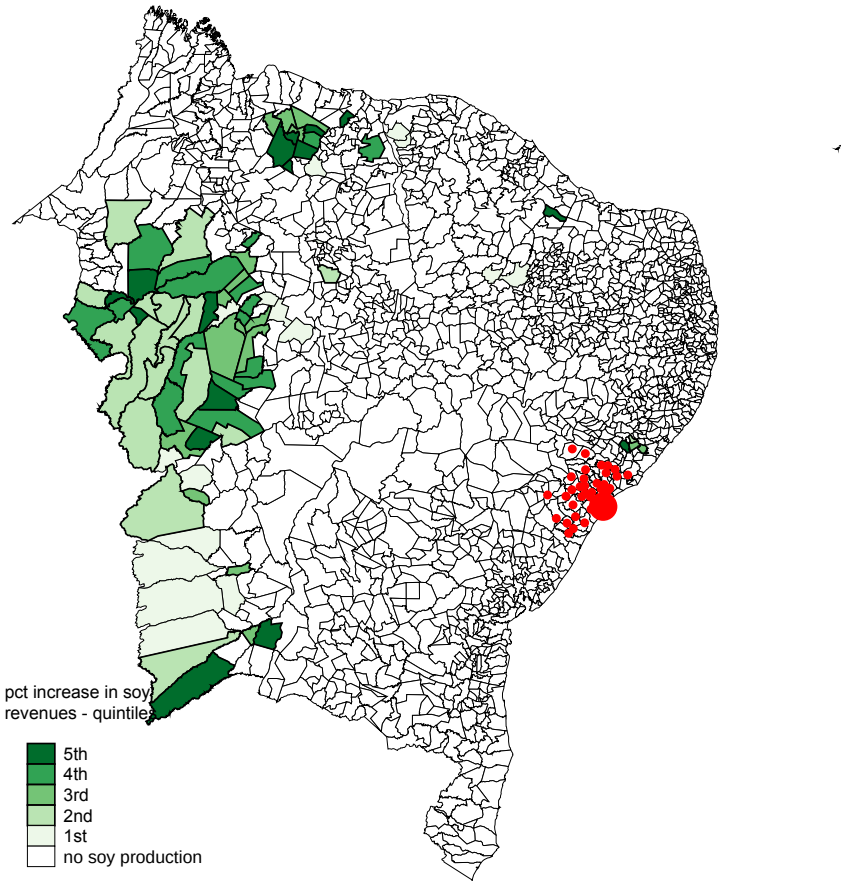
High Exposure

Coastal municipalities in South Brazil



Low Exposure

Coastal municipalities in North-East Brazil



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3. Reallocation of capital across firms: **low → high productivity ?**
   - We exploit pre-existing firm-bank relationships
   - Match administrative data on credit and employment relationships for universe of formal firms
   - Estimate effect on borrowing and firm growth (extensive and intensive margin)

Findings

Local effects

- Regions where GE soy had larger *potential* impact on profitability:
  - $\uparrow$ agricultural profits
  - $\uparrow$ deposits in local bank branches
  - No increase in loans

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Reallocation through bank branch network

- Firms located in municipalities served by more exposed banks
  - ↑ probability of accessing bank finance

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    → but 99 percent of soy-driven new capital went to non-agricultural sectors

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- Firms with pre-existing relationships with more exposed banks
  - ↑ borrowing in all sectors
    → but 99 percent of soy-driven new capital went to non-agricultural sectors
  - ↑ employment and wage bill in all sectors
    → but 97 percent of soy-driven employment growth occurred in non-agricultural sectors

Related Literatures

Financial development and industrialization:

- Bagehot (1873), Hicks (1969), Levine (1997, 2005), Crafts (1985), Crouzet (1972).

Agricultural productivity and structural transformation:

- Foster and Rosenzweig (2004, 2008), Nunn and Qian (2011), Hornbeck and Keskin (2014), Bustos, Caprettini, Ponticelli (2016)

Dynamic Heckscher-Ohlin models:

- Stiglitz (1970), Findlay(1970), Ventura (1997), Acemoglu and Guerrieri (2008)

Financial frictions and economic development:

- Macro: Gine and Townsend (2004), Jeong and Townsend (2008), Buera Kaboski and Shin (2011), Moll (2014)
- Micro: McKenzie and Woodruff (2008); Mckenzie, De Mel and Woodruff (2009), Banerjee and Duflo (2014); Banerjee, Karlan, and Zinman (2015); Banerjee, Duflo, Glennerster and Kinnan (2013)

Financial and real effects of bank liquidity shocks:

- Khwaja and Mian (2008), Schnabl (2012), Amiti and Weinstein (2011), Jimenez, Mian, Peydro, and Saurina (2014), Agarwal, Chomsisengphet, Mahoney, Stroebel (2015), Gilje, Loutskina and Strahan (2015)

Structure of Talk

1. Data and background
   - Firms and bank credit in Brazil
   - GE soy and boom in agriculture
2. Local effects
   - Effect of soy productivity growth on local deposits and credit
3. Reallocation through bank branch network
   - Intensive margin: credit and growth in firms with pre-existing bank relationships
   - Extensive margin: credit market participation in destination municipalities

Firms and Bank Credit in Brazil
Data: 1997-2010

- Datasets
  - Credit Information System (CRC + SCR) source: Central Bank of Brazil
  - Annual Social Information System (RAIS) source: Ministry of Labor
- Coverage
  - Universe of loans from Credit Registry
  - Universe of formal firms from Employer-Employee Data
- Match
  - Bank-firm level loans with firm-level employment and wages

Firms and Bank Credit in Brazil
Data: 1997-2010

Advantages

- Observe not only firms with credit but also firms who never accessed credit
  - Allows to study credit market participation (extensive margin)
- Observe the universe of formal firms
  - Allows to study capital allocation across all sectors and firms of all sizes

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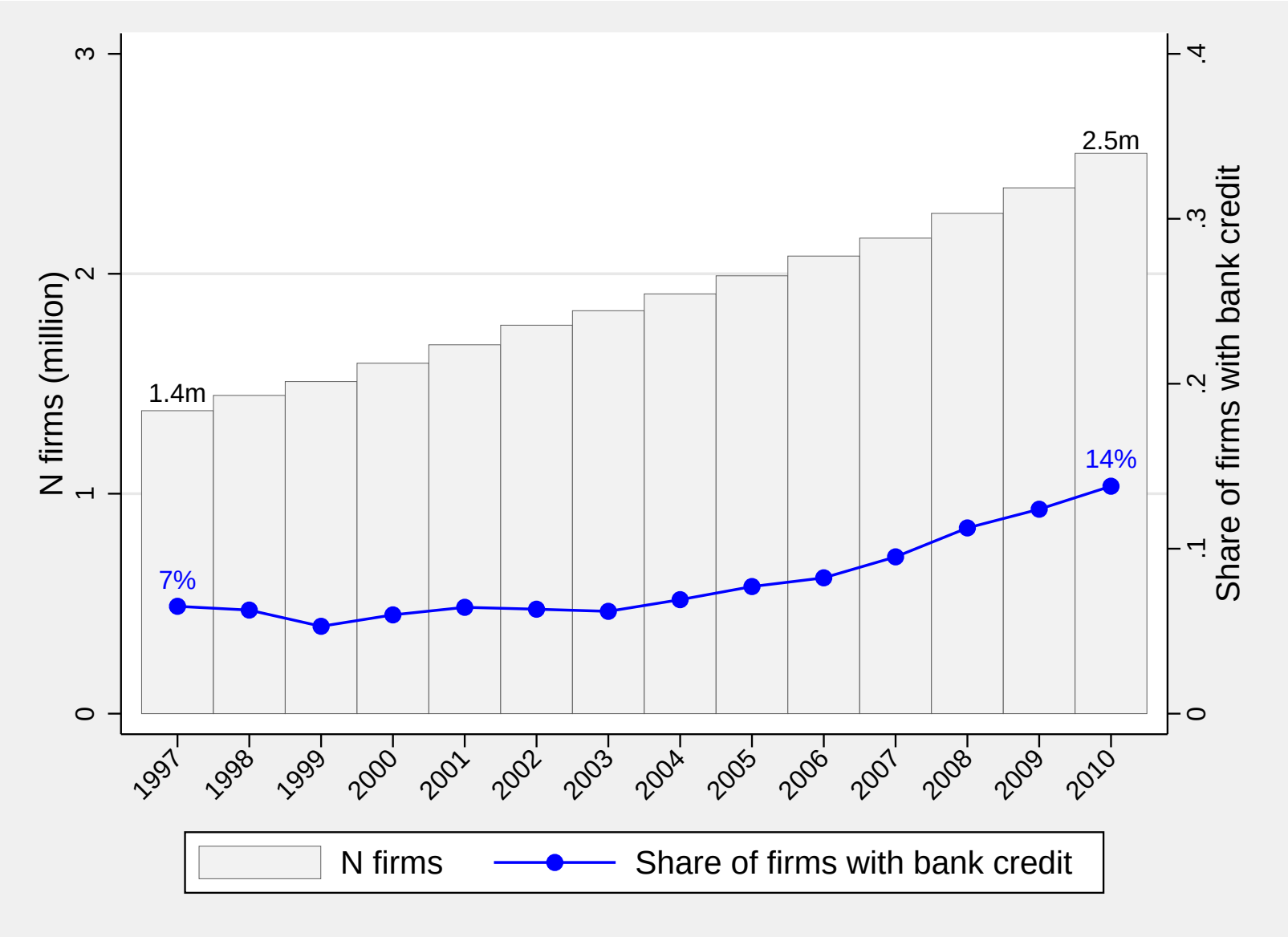
Caveats

- Observe only formal firms with employees
- Access to credit $=$ outstanding balance $\geq$ CR reporting treshold
  - year 1997 onwards: 50,000 R$ ($\approx$ 45,000 USD)
    - 1.5 wL micro firms, 0.25 wL small firms
  - year 2001 onwards: 5,000 R$ ($\approx$ 2,500 USD)
    - 0.16 wL micro firms, 0.03 wL small firms

Share of Firms with Bank Credit

Brazil: 1997-2010

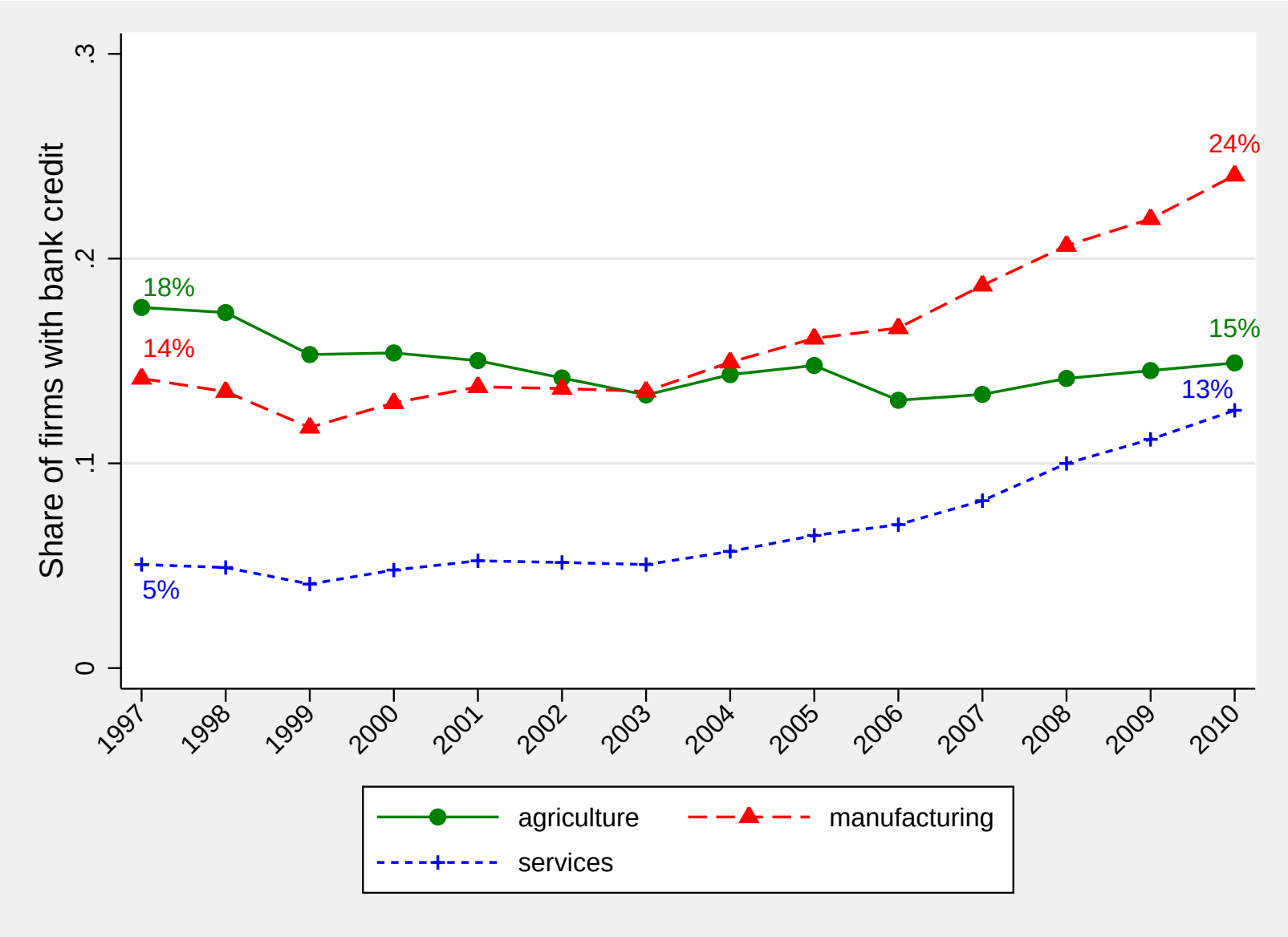


Source: Credit Information System of the BCB and RAIS, authors' calculation from micro-data

2001-2010 - 5000 threshold

Share of Firms with Bank Credit: by Sector

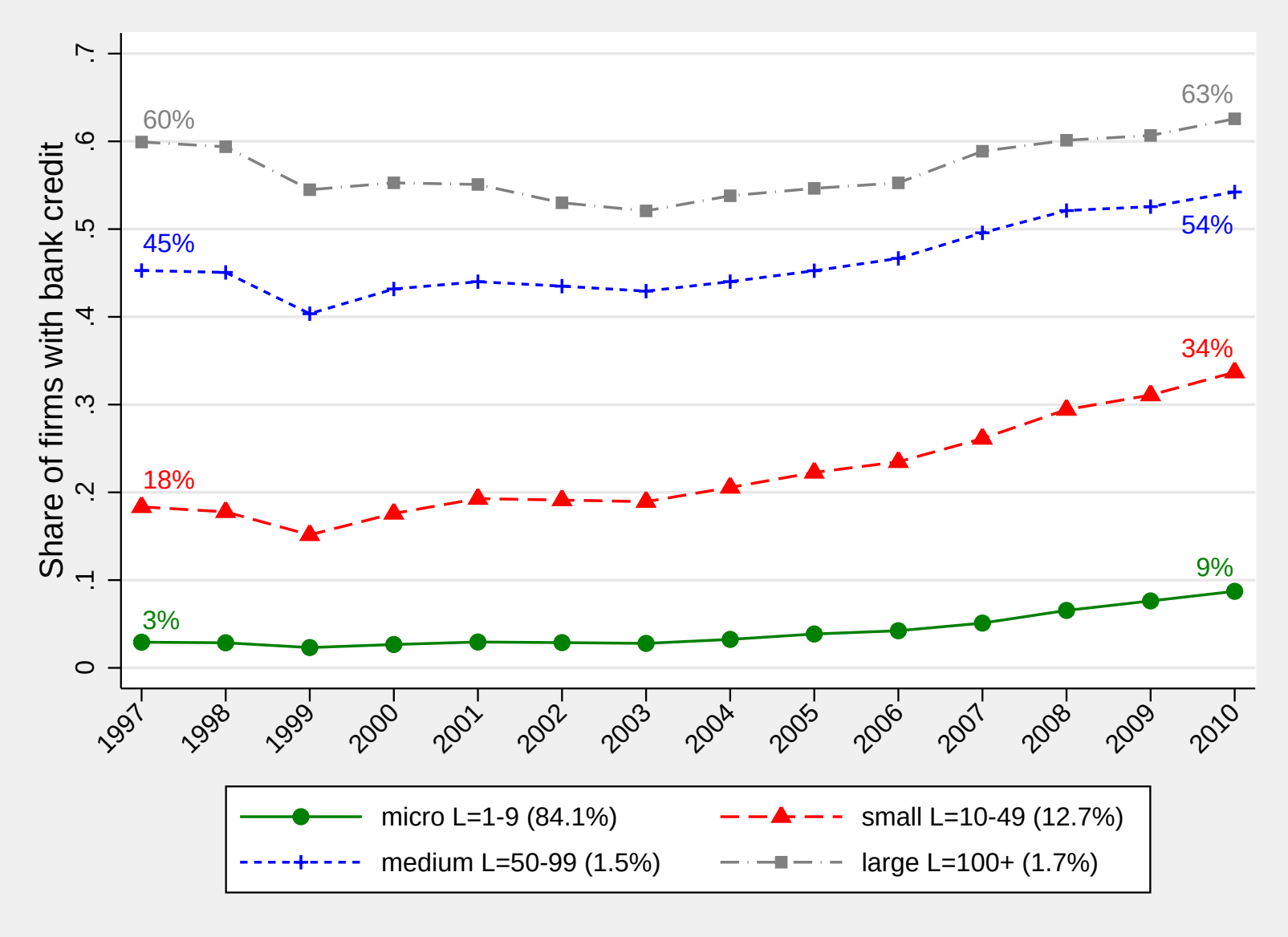
Brazil: 1997-2010



Source: Credit Information System of the BCB and RAIS, authors' calculation from micro-data. Services include: construction, commerce, lodging and restaurants, transport, housing services, domestic workers.

Share of Firms with Bank Credit: by Firm Size

Brazil: 1997-2010



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Background
Genetically Engineered Soy

In 2003, Brazil legalizes the use of genetically engineered soy seeds

This genetic modification:

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3. Makes soy production in tropical areas profitable

Background

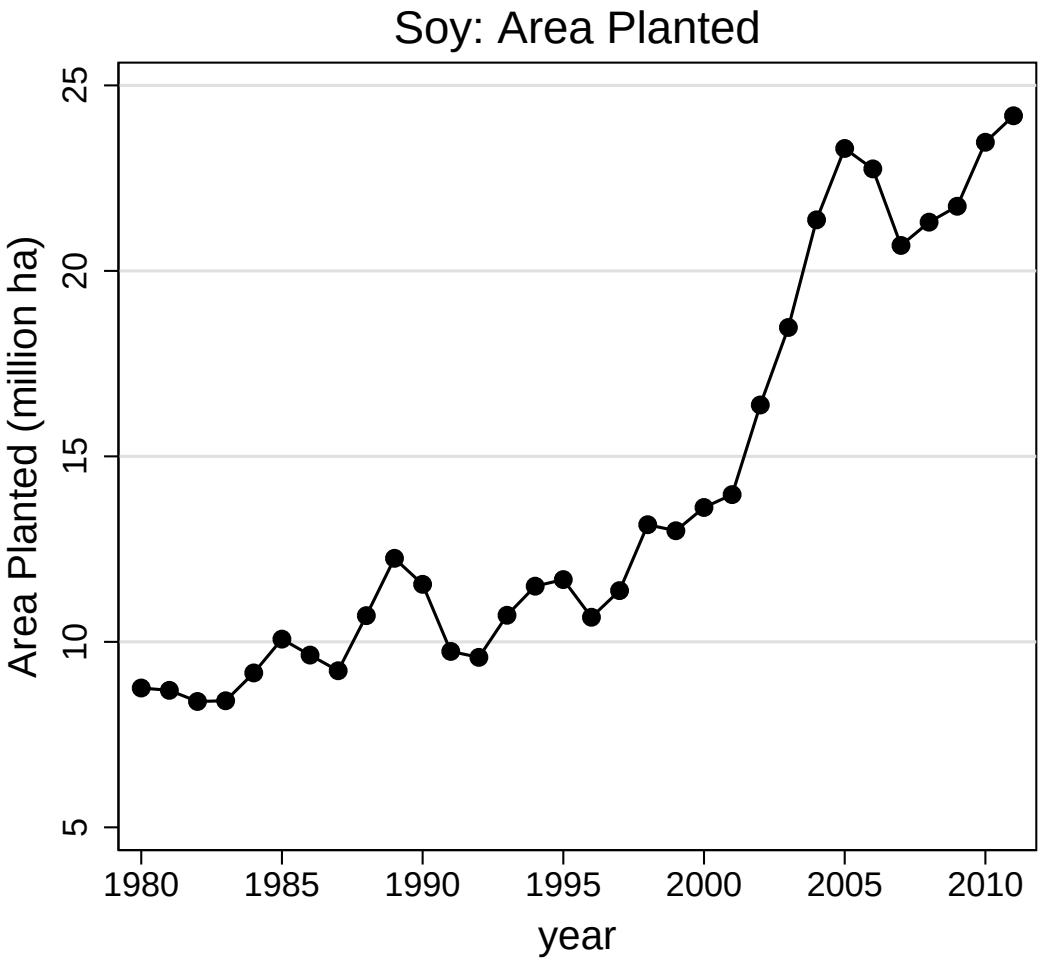
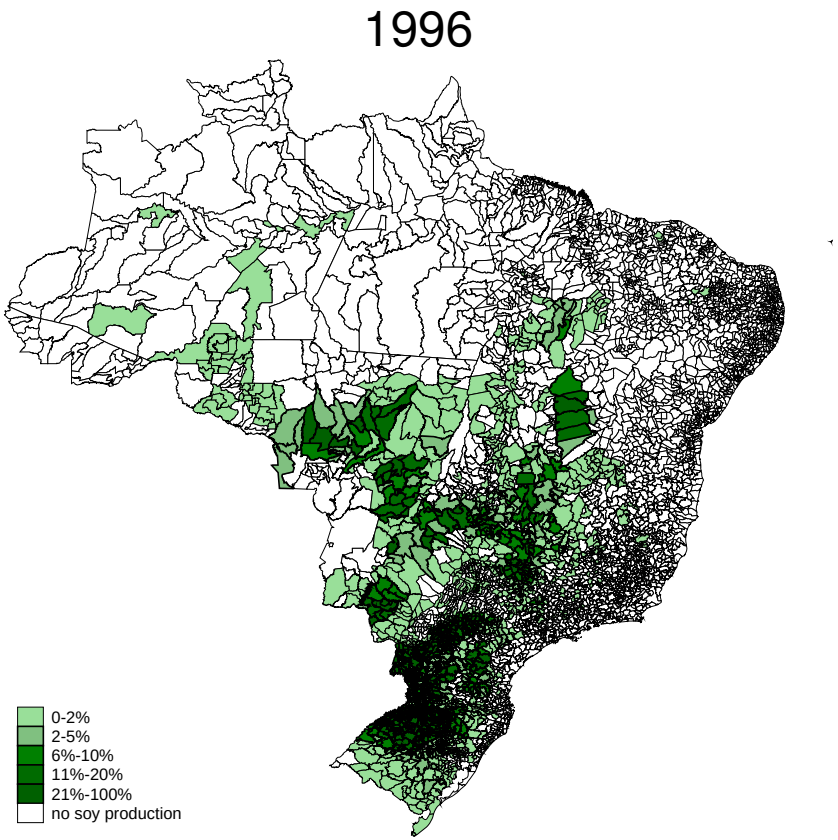
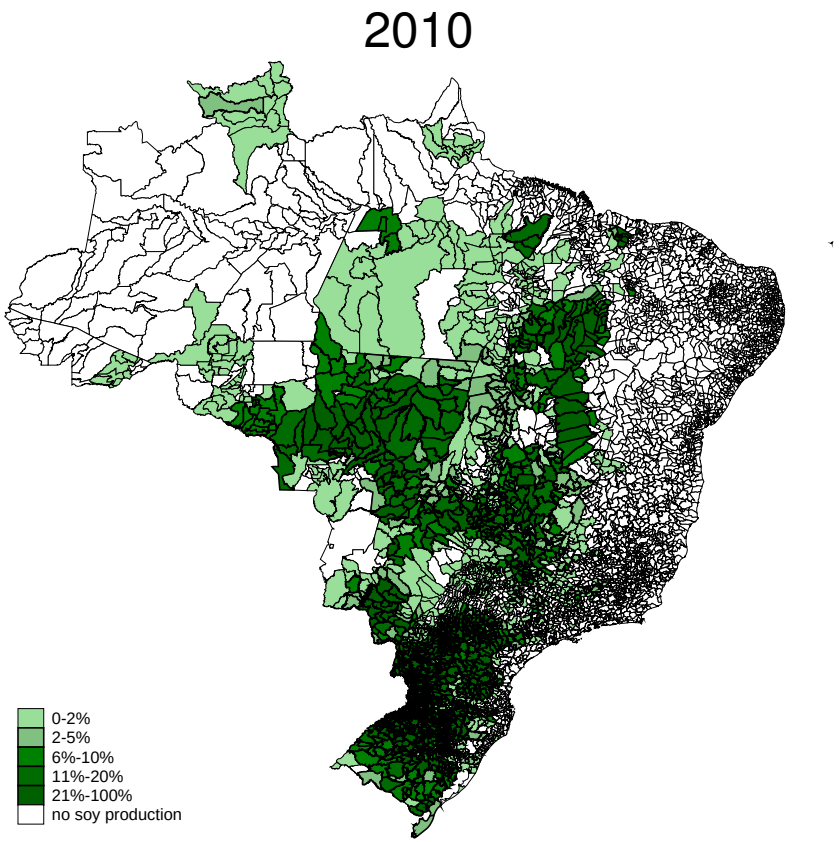


Figure with international soy price

Background

Geographical Expansion: Share of Soy in Area Planted





GE Soy Boom and Reallocation
Datasets

Local Effects

- Agricultural Census: 1996 and 2006 (IBGE)
  - municipality-level data on GE soy adoption and profits
- Municipal Agricultural Production Survey (PAM)
  - municipality-level yearly data on cultivated area and revenues
- Potential crop yields (FAO-GAEZ)
  - geo-referenced grid of 9.25 $\times$ 9.25 km by crop and level of technology

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Reallocation through bank branch network

- Municipal Bank Statistics (ESTBAN) source: Central Bank of Brazil
  - balance sheet for all branches of commercial banks ($\approx$ 115 banks/year)

Structure of Talk

1. Data and background
2. **Local effects**
   - Effect of soy productivity growth on local deposits and credit
3. Reallocation through bank branch network

Empirics
Identification Strategy I: Local Effects

Baseline Reduced Form:

$$y_{jt} = \alpha_j + \alpha_t + \beta \log(A_{jt}^{soy}) + \varepsilon_{jt}$$

where:

- A_{jt}^{soy}: *potential* increase in soy yield due to technical change in municipality j

Measure of Potential Soy Yield: A_{jt}^{soy}

FAO-GAEZ: agronomic model for potential yields attainable in each crop

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FAO-GAEZ: agronomic model for potential yields attainable in each crop

Ingredients of the model:

1. Soil and weather characteristics
2. Crop-specific model parameters
3. Assumptions about technology:
   - LOW inputs: traditional agriculture
   - $HIGH$ inputs: intensive use herbicides/fertilizers, HYV of seeds

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Output of the model:

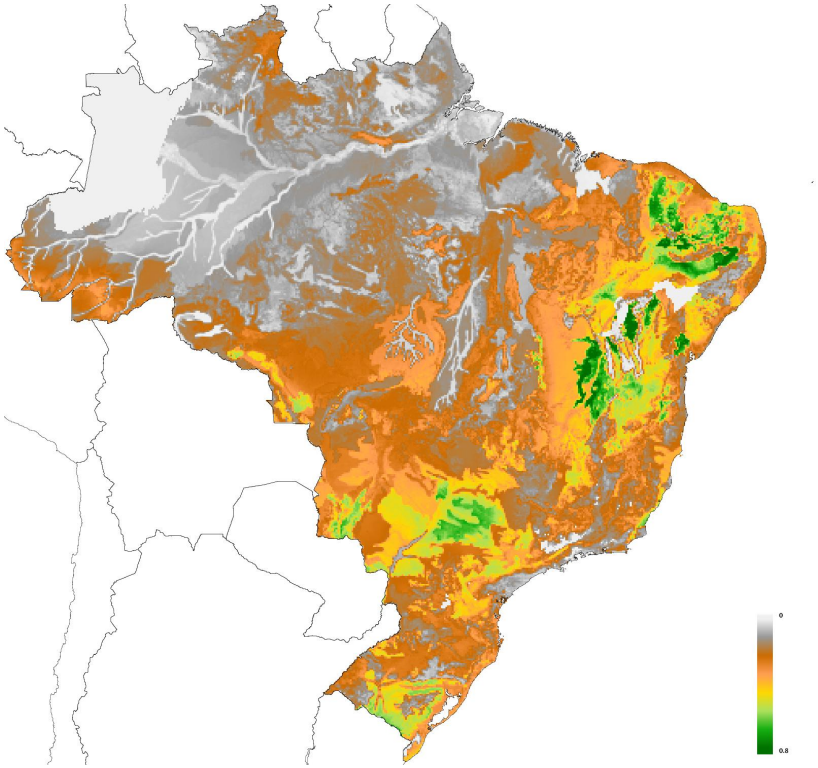
$\Rightarrow$ Potential soy yields (t per ha) for worldwide grid of 9.25 x 9.25 km

Measure of Potential Soy Yield

source: FAO-GAEZ dataset

LOW inputs: $A_j^{\text{soy,LOW}}$

HIGH inputs: $A_j^{\text{soy, HIGH}}$



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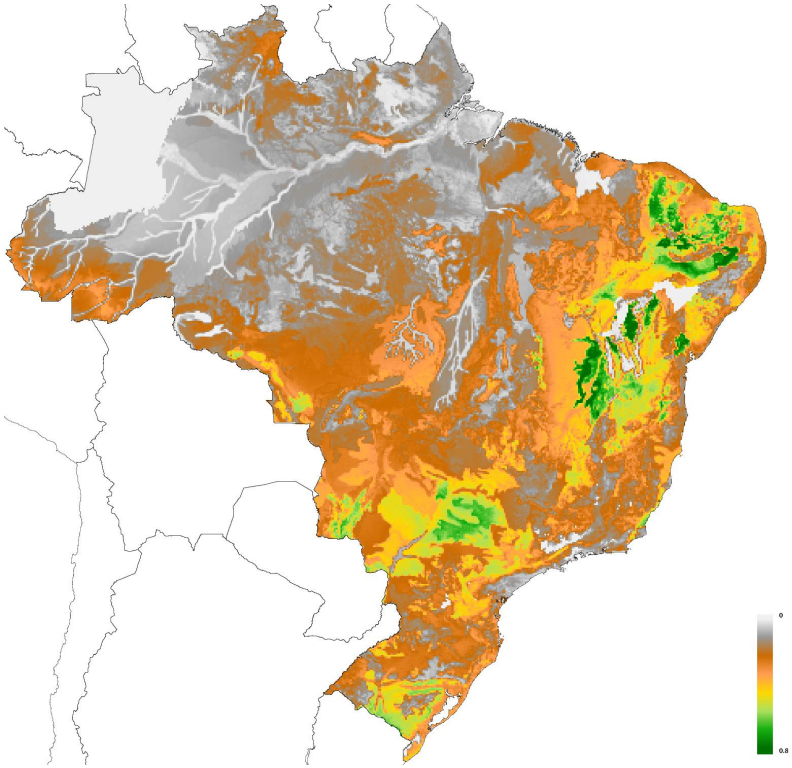
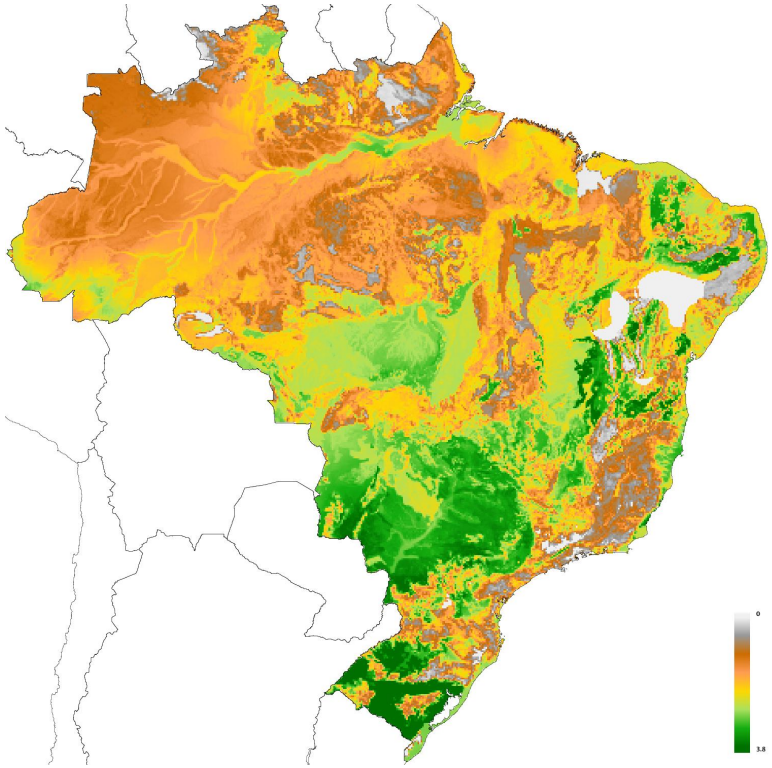
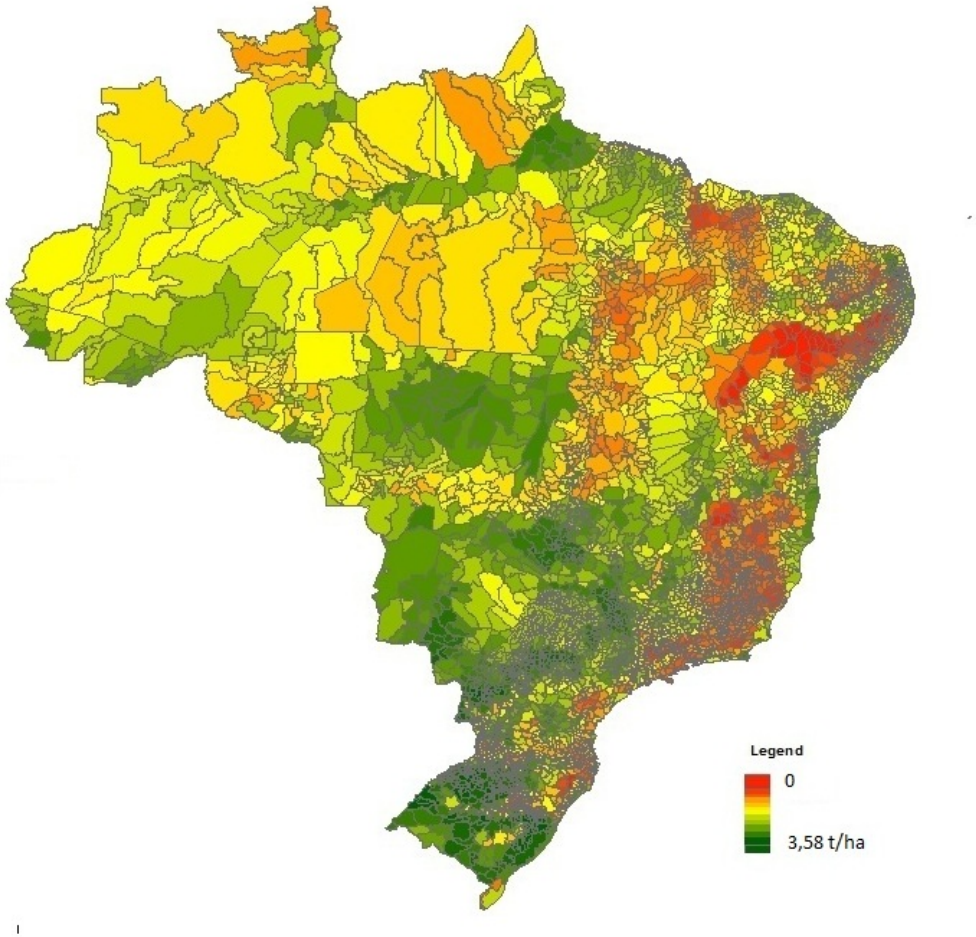


HIGH inputs: $A_j^{\text{soy, HIGH}}$



Increase in Potential Soy Yield

$$\Delta A_j^{\text{soy}} = A_j^{\text{soy, HIGH}} - A_j^{\text{soy, LOW}}$$



Local Effects

Agricultural Census Data: 1996 and 2006

$$\Delta y_{jt} \quad = \quad \alpha + \beta \Delta \log(A_j^{soy}) + \varepsilon_{jt}$$

where:

$$\Delta \log(A_j^{soy}) = \log A_j^{\text{soy, HIGH}} - \log A_j^{\text{soy, LOW}}$$

Dep var:	$\Delta \frac{\text{GE Soy Area}}{\text{Agri Area}}$ (1)	$\Delta \frac{\text{Non-GE Soy Area}}{\text{Agri Area}}$ (2)	Δ Profits per he (%) (3)	Δ Investment per he (%) (4)
$\Delta \log A^{soy}$	0.033***	-0.016***	0.229***	0.214***
	[0.003]	[0.003]	[0.079]	[0.048]
Observations	3,020	3,020	3,020	3,020
R-squared	0.152	0.044	0.014	0.018
Avg in 1996:			144 R$/he	49 R$/he

Robust standard errors reported in brackets. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

All regressions include municipality controls $X_{j,t=0}$: share rural pop, log gdp pc, pop density, literacy rate (Pop Census 1991).

Local Effects

Quantification

- *Potential* increase in soy yield due to technical change
  - predicts increase in agricultural profits: 10.7% for 1 s.d. in ΔA_j^{soy}
- Estimates suggest that for every 10 R$ increase in profits per he:
  - 3.45 R$ re-invested
  - 6.65 R$ consumed or saved

Local Effects

PAM and ESTBAN Yearly Data: 1996-2010

$$y_{jt} = \alpha_j + \alpha_t + \beta \log(A_{jt}^{soy}) + \varepsilon_{jt}$$

where:

$$A_{jt}^{soy} = \begin{cases} A_j^{soy,LOW} & \text{for } t < 2003 \\ A_j^{soy,HIGH} & \text{for } t \geq 2003 \end{cases}$$

	Agriculture		Banking sector	
	$\frac{\text{Soy Area}_t}{\text{Agri Area}_{96}}$	$\log$ (revenues soy farmers $+1$)	$\log$(deposits in local branches)	$\log$(loans from local branches)
	(1)	(2)	(3)	(4)
$\log A_{jt}^{soy}$	0.014	0.181	0.061	-0.056
	[0.002]***	[0.087]**	[0.015]***	[0.028]**
Observations	44,524	44,524	44,524	44,524
R-squared	0.976	0.894	0.976	0.952
N clusters	3177	3177	3177	3177

Standard errors clustered at municipality level reported in brackets. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

All regressions include: municipality and time fixed effects, as well as municipality controls interacted with time fixed.

Local Effects

Quantification

- *Potential* increase in soy yield due to technical change
  - predicts increase in deposits in local branches: 7% for 1 s.d. in A_{jt}^{soy}
- Implied elasticity of local bank deposits to soy revenues:
  - 10 % $\uparrow$ in revenues soy farmers $\rightarrow$ 3.4% $\uparrow$ bank deposits
- Lower lending originated by same local bank branches

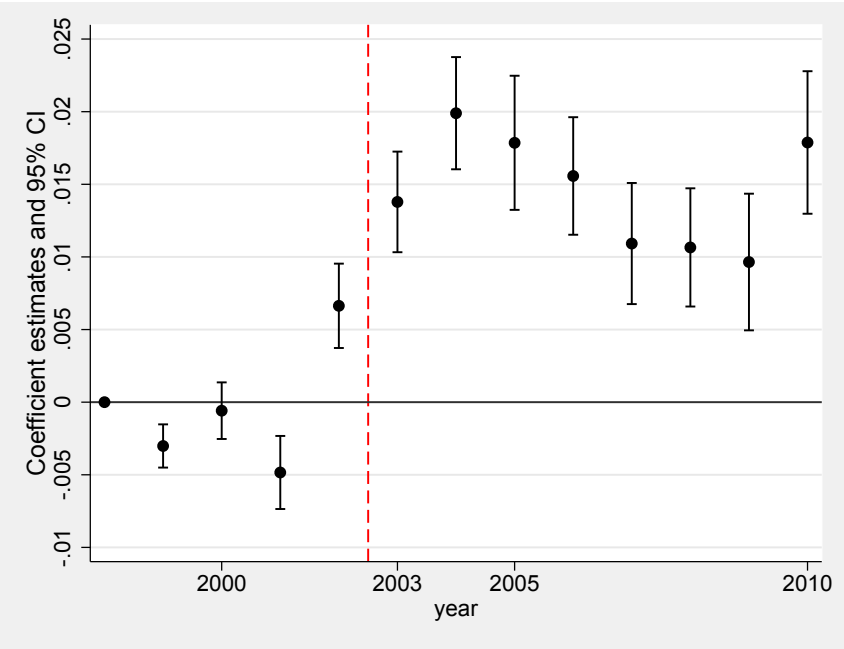
$\rightarrow$ capital exports

Timing

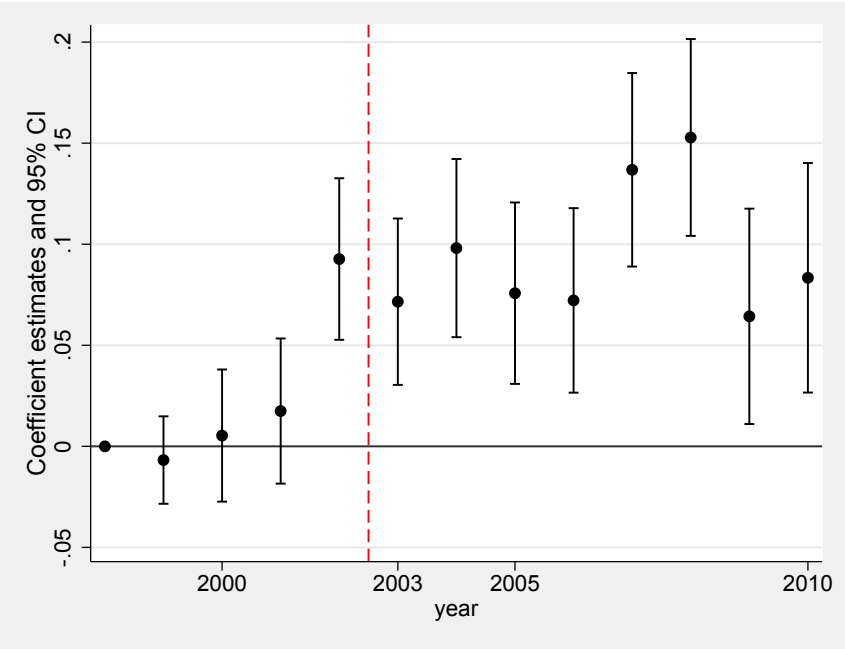
Effect of technical change on soy area and bank deposits

$$y_{jt} \quad = \quad \alpha_j + \alpha_t + \beta_t \, \Delta \log(A_j^{soy}) + \varepsilon_{jt}$$

$y_{jt} =$ soy area / agricultural area



$y_{jt} = log$ (deposits)

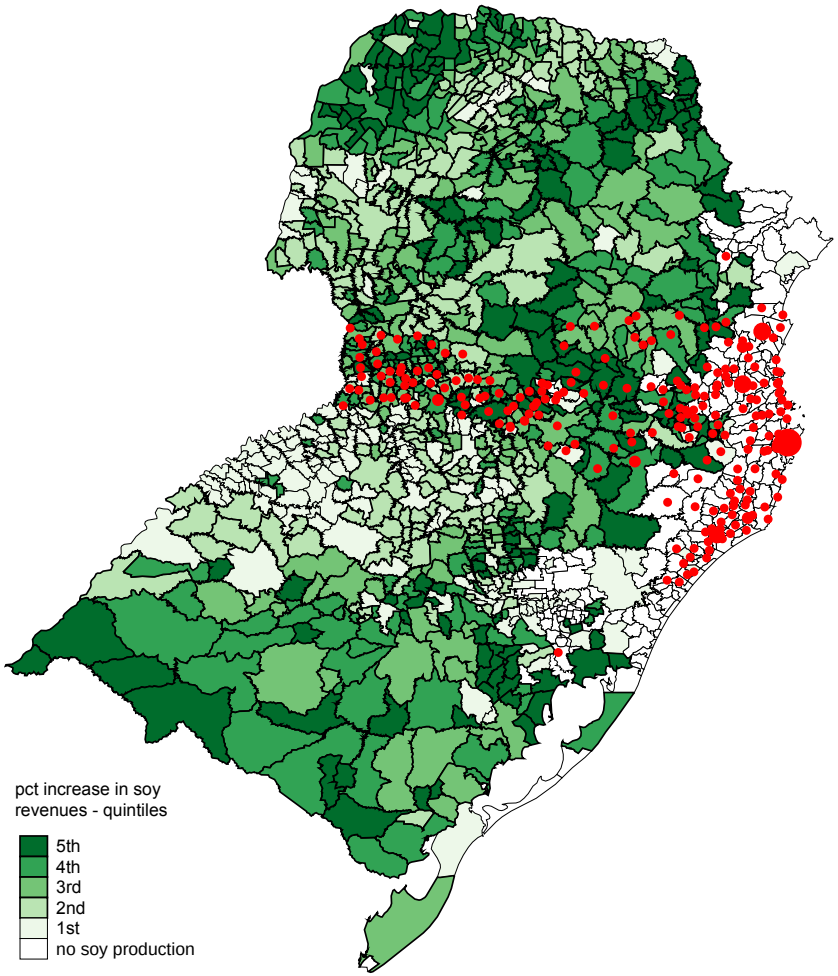


Structure of Talk

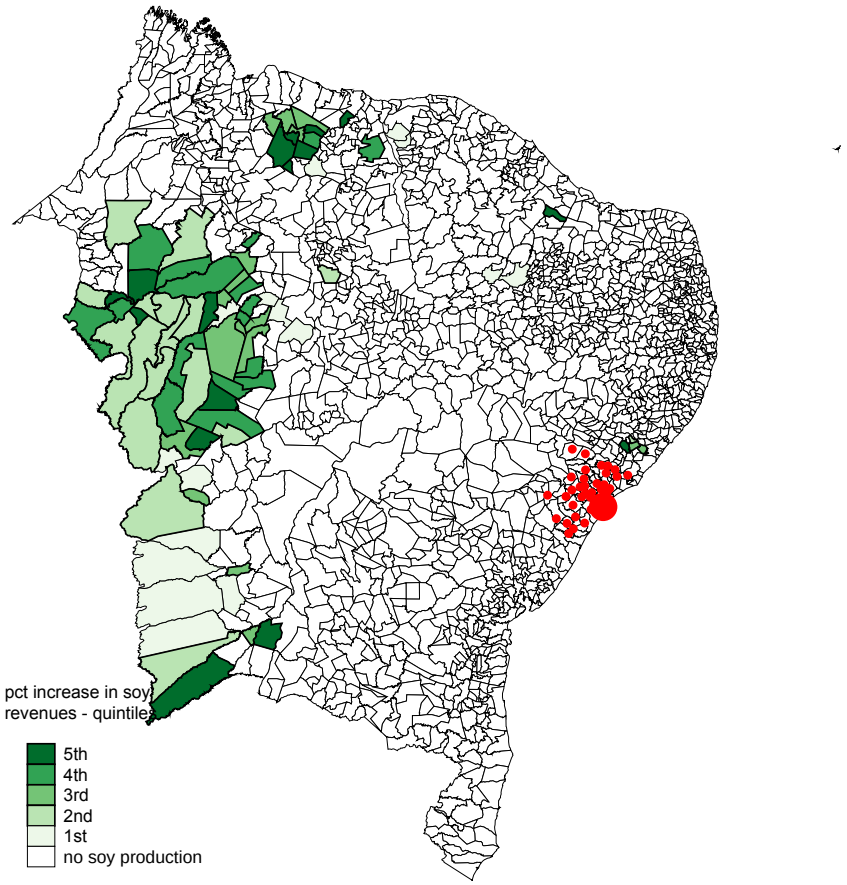
1. Data and background
2. Local effects
3. **Reallocation through bank branch network**
   - Estimate bank exposure to soy boom in *origin* municipalities
   - Estimate effect of credit supply shock on firms in *destination* municipalities

Illustrative Example

Bank A:
high exposure to soy boom
(South Brazil)



Bank B:
low exposure to soy boom
(North-East Brazil)



Bank Exposure

- National deposits of bank b at time t are:

$$Deposits_{bt} = \sum_{o \in O_{b,t}} deposits_{bot}$$

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- If deposits are a log-linear function of income, our model implies that deposits in the branches of bank b located in municipality o are:

$$\log(deposits)_{bot} = \alpha_b + \alpha_o + \alpha_t + \beta \left(\frac{T^a_{o,t}}{T_{o,t}} \right) (\log A_{o,t}) + \varepsilon_{bot} \tag{1}$$

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$$\log(deposits)_{bot} = \alpha_b + \alpha_o + \alpha_t + \beta \left(\frac{T^a_{o,t}}{T_{o,t}} \right) (\log A_{o,t}) + \varepsilon_{bot} \tag{1}$$

- To simplify aggregation, we obtain a log-linear approximation to the change in national deposits of bank b:

$$d \log (Deposits)_b \approx \sum_{o \in O_{b,t=0}} \omega_{bo,t=0} \; d \log (deposits)_{bo}$$

where: $\omega_{bo,t=0} = \frac{deposits_{bo,t=0}}{Deposits_{b,t=0}}$

Bank Exposure, cont

- Next, we substitute $d\log(deposits)_{bo}$ by equation (1) and obtain:

$$\begin{aligned}\log Deposits_{b,t} &= \log Deposits_{b,t=0} + \sum_{o\in O_b} \omega_{bo}\ \beta\ \frac{T_o^a}{T_o}\ (\log A_{o,t} - \log A_{o,t=0}) \\ &\quad + (\alpha_t - \alpha_{t=0}) + \sum_{o\in O_b} \omega_{bo}\,(\varepsilon_{bot} - \varepsilon_{bo,t=0})\end{aligned}$$

Add bank and time fixed effects, to obtain:

$$\log Deposits_{bt} = \gamma_b + \gamma_t + \beta \underbrace{\sum_{o\in O_b} \omega_{bo}\ \frac{T_o^a}{T_o}\ \log A_{o,t}}_{BankExposure_{bt}} + \eta_{bt} \tag{2}$$

Bank Exposure, cont

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Bank Exposure and Deposits

	$\log Deposits_{bt}$		
	(1)	(2)	(3)
BankExposure$_{bt}$	1.297**	1.457**	1.539**
	[0.624]	[0.575]	[0.690]
log(assets)$_{b,t=0} \times t$		y	y
(deposits/assets)$_{b,t=0} \times t$			y
log (N branches)$_{b,t=0} \times t$			y
fixed effects:			
bank	y	y	y
year	y	y	y
Observations	967	967	967
R-squared	0.927	0.927	0.928
F-stat	4.321	3.851	2.029
N clusters	115	115	115

Standard errors clustered at bank level in brackets. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Observation weighted by bank assets in 1996.

- implied elasticity of bank deposits to income: 1.3

Reallocation: intensive margin

Firm-bank level specification

- Estimate effect of bank exposure on borrowing by firms with pre-existing relationship:

$$\log(loan_{ibdt}) = \delta_i + \delta_b + \delta_d + \delta_t + \gamma\ BankExposure_{bt} + \varepsilon_{ibdt} \tag{4}$$

i: firm, b: bank, d: destination municipality, t: time

where

$$BankExposure_{bt} = \sum_{o \in O_b} \omega_{bo}\ \frac{T_o^a}{T_o}\ \log A_{o,t}$$

Intensive margin

Identification assumption:

Soy driven credit supply change at bank-level uncorrelated with credit demand changes at firm-level

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Soy driven credit supply change at bank-level uncorrelated with credit demand changes at firm-level

- Potential violations:
  - Firms receiving larger product demand from richer farmers
  - Firms facing larger labor supply from former agricultural workers
  - Firms supplying/ buying inputs for soy production

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- To address those:
  - Focus on firms operating in non-soy producing regions
  - Exclude firms operating in sectors directly linked to soy (using IO Table)
- However, regions more connected through bank networks can also be more connected through transportation, migrant networks or commercial links
  - Add interaction of municipality $\times$ time fixed effects

Intensive margin

Firm-bank level specification

- Firm-bank level specification that we estimate

$$\log(loan_{ibdst}) = \delta_i + \delta_b + \delta_t + \delta_{dt} + \delta_{st} + \gamma BankExposure_{bt} + \varepsilon_{ibdst} \quad (5)$$

i: firm, b: lender, d: destination municipality, s: sector, t: time

Summary statistics

variable	mean	median	st.dev.	N obs
employment (n workers)	45	7	550	1,551,393
agriculture	70	13	263	9,206
manufacturing	58	13	378	274,703
services	32	6	342	1,189,432
other	188	14	1919	78,052
loan (th R$)	927	47	25,186	1,551,393
agriculture	1,250	84	7,814	9,206
manufacturing	2,125	85	34,208	274,703
services	534	42	15,332	1,189,432
other	2,663	43	69,926	78,052

Formal firms with at least 1 employee and access to bank finance. Years: 2001-2010.

Loan variable deflated using IPCA index (consumer price index from IBGE), base: January 2014

Intensive margin

Firm-bank level specification

outcome:	log loan	
sample:	all firms	multi-lender firms
	(1)	(2)
$BankExposure_{bt}$	0.277	0.211
	[0.106]***	[0.093]**
fixed effects:		
firm	y	y
bank	y	y
year	y	y
AMC × year	y	y
Sector (2d CNAE) × year	y	y
firm × year		y
Observations	2,795,805	1,646,097
R-squared	0.550	0.658
N clusters	115	115

Standard errors clustered at bank level in brackets. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

- elasticity of firm credit to deposits due to soy shock: 0.21 = 0.28 /1.3

Intensive margin

Firm-bank level specification: heterogeneous effects by sector

	log loan			
Sector:	Agriculture (1)	Manufacturing (2)	Services (3)	Other (4)
$BankExposure_{bt}$	0.125	0.304	0.266	0.228
	[0.211]	[0.158]*	[0.096]***	[0.177]
fixed effects:				
firm	y	y	y	y
year	y	y	y	y
bank	y	y	y	y
AMC $\times$ year	y	y	y	y
Sector (2d CNAE) $\times$ year	y	y	y	y
Observations	12,588	581,003	2,057,719	130,985
R-squared	0.685	0.571	0.527	0.595
N clusters	73	113	115	95

Standard errors clustered at bank level in brackets. Significance levels: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Intensive margin

Firm-level specification: real effects

- Firm-level specification that we estimate

$$\log(y_{ibdst}) = \delta_i + \delta_t + \delta_{dt} + \delta_{st} + \gamma FirmExposure_{it} + \varepsilon_{ibdst} \tag{6}$$

i: firm, d: destination municipality, s: sector, t: time

where:

$$FirmExposure_{it} = \sum_{b \in B} \pi_{ib,t=0} \;\; BankExposure_{bt}$$

and

$$\pi_{ib,t=0} = \frac{loans_{ib,t=0}}{Loans_{i,t=0}}$$

Intensive margin

Firm-level specification: real effects

	log employment		log wage bill	
	(1)	(2)	(3)	(4)
$FirmExposure_{it}$	0.135	0.130	0.186	0.175
	[0.040]***	[0.038]***	[0.042]***	[0.040]***
fixed effects:				
firm	y	y	y	y
year	y	y	y	y
AMC $\times$ year	y	y	y	y
Sector (2d CNAE) $\times$ year		y		y
Observations	1,551,295	1,551,294	1,551,295	1,551,294
R-squared	0.894	0.894	0.911	0.911
N clusters	115	115	115	115

Standard errors clustered at main lender level in brackets. Significance levels: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Intensive margin

Firm-level Specification: Real Effects by Sector

indep var: $FirmExposure_{it}$	log employment (1)	log wage bill (2)
Agriculture	0.330	0.330
	[0.134]**	[0.141]**
Observations	5,410	5,410
N clusters	53	53
Manufacturing	0.158	0.221
	[0.050]***	[0.054]***
Observations	268,864	268,864
N clusters	101	101
Services	0.131	0.169
	[0.037]***	[0.037]***
Observations	1,184,883	1,184,883
N clusters	111	111
fixed effects in all specifications		
firm	y	y
year	y	y
AMC $\times$ year	y	y
Sector (2d CNAE) $\times$ year	y	y

Standard errors clustered at main lender level in brackets. Significance levels: *** p$<$0.01, ** p$<$0.05, * p$<$0.1.

Quantification

- Allocation across sectors of **1R$ of new loans** from soy-driven deposit shock:

	Agriculture	Manufacturing	Services	Other
new loans in R$	0.01	0.37	0.49	0.13

Notes: Based on average loan size and number of firms by sector

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new loans in R$	0.01	0.37	0.49	0.13

Notes: Based on average loan size and number of firms by sector

- Allocation across sectors of **100 extra workers** from soy-driven deposit shock:

	Agriculture	Manufacturing	Services	Other
employment in units	3	31	64	2

Notes: In percentage points for 1 percent increase in bank credit

Reallocation through bank branch network
Extensive margin

- Construct *destination* municipality-level credit supply shock:

$$MunicipalityExposure_{dt} = \sum_b \frac{l_{bd}}{L_d} BankExposure_{bt}$$

$\frac{l_{bd}}{L_d} \approx$ lending market share of bank b in destination municipality d

Reallocation through bank branch network
Extensive margin

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$$MunicipalityExposure_{dt} = \sum_b \frac{l_{bd}}{L_d} BankExposure_{bt}$$

$\frac{l_{bd}}{L_d} \approx$ lending market share of bank b in destination municipality d

- Study effect on credit market participation

$$I_{dt} = \alpha_d + \alpha_t + \beta MunicipalityExposure_{dt} + \varepsilon_{dt} \tag{7}$$

I_{dt}: share of firms in destination municipality d with access to bank credit

Extensive margin

outcome variables:	Bank Credit Participation		
	all firms	micro and small	medium and large
	(1)	(2)	(3)
Municipality exposure	0.012	0.010	0.009
	[0.005]**	[0.005]**	[0.024]
fixed effects:			
municipality	y	y	y
year	y	y	y
municipality controls × year	y	y	y
Observations	27,007	26,908	25,949
R-squared	0.466	0.453	0.553
N clusters	1936	1936	1936

- Destination municipalities with 1 sd higher exposure:

  → 0.2 pp larger increase in credit market participation (mean: 5.6%)

Conclusions

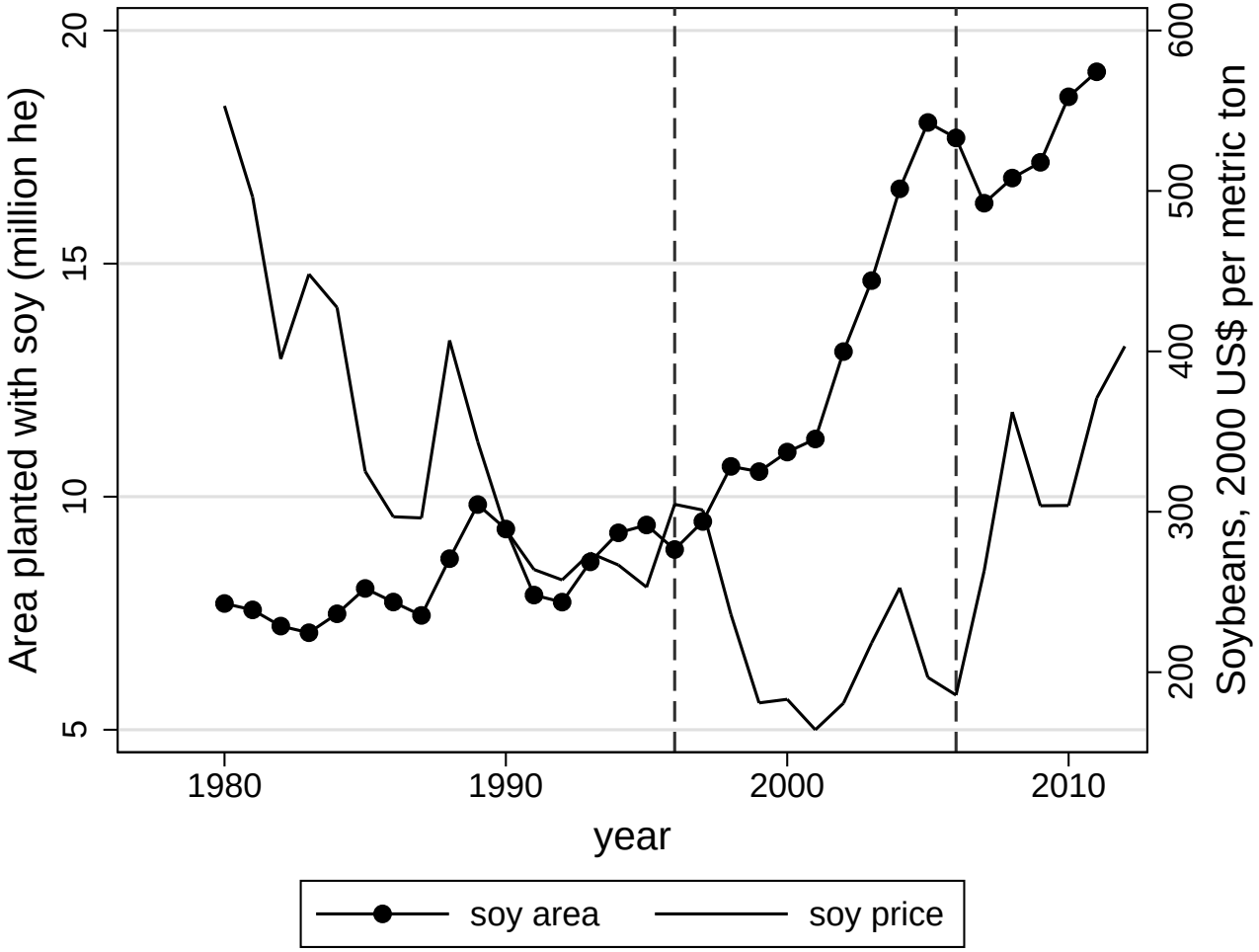
Findings

1. Adoption of the new agricultural technology generated savings deposits in rural areas
2. Banks reallocated new capital to
   - other regions within the country
   - manufacturing and service sectors
3. New credit led to growth in employment and wage bill
   - elasticity of firm employment growth to credit: 0.47
   - elasticity of firm wage bill growth to credit: 0.63

Agricultural productivity growth can lead to structural transformation through a finance channel

Background

Expansion of GE soy and Soy Price

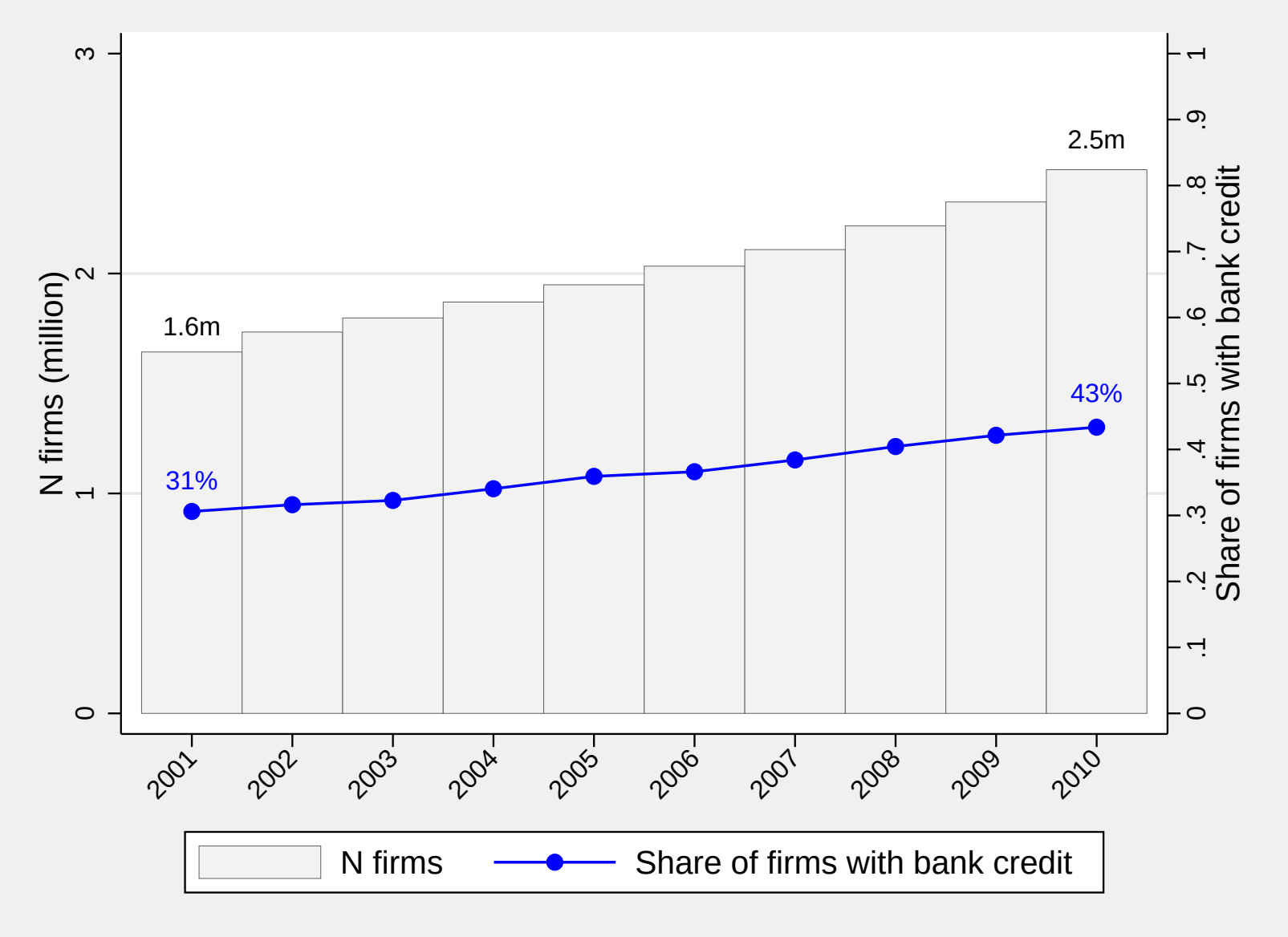


Source: CONAB

back

Share of Firms with Bank Credit

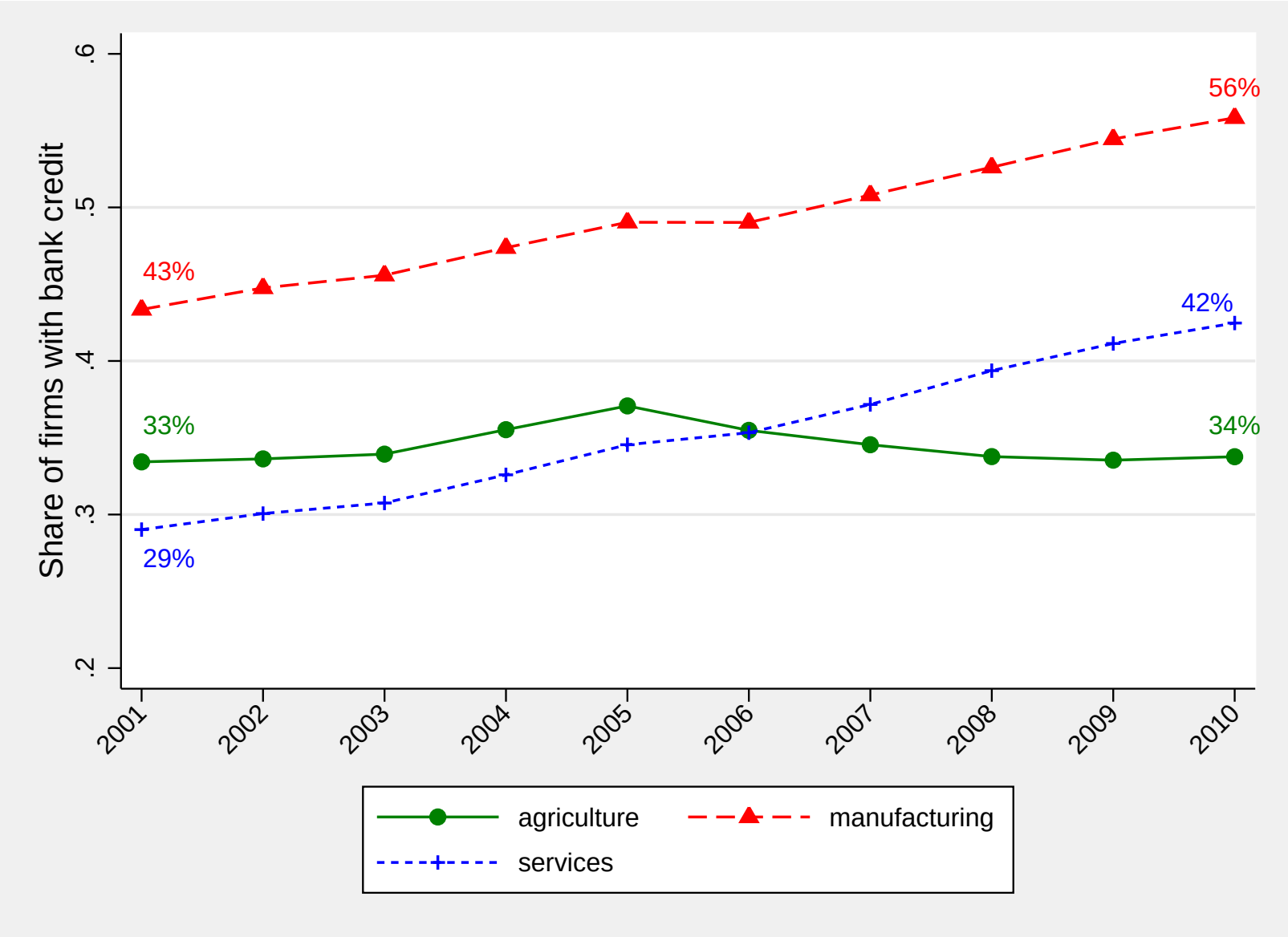
Brazil: 2001-2010



Source: Credit Information System of the BCB and RAIS, authors' calculation from micro-data

Share of Firms with Bank Credit: by Sector

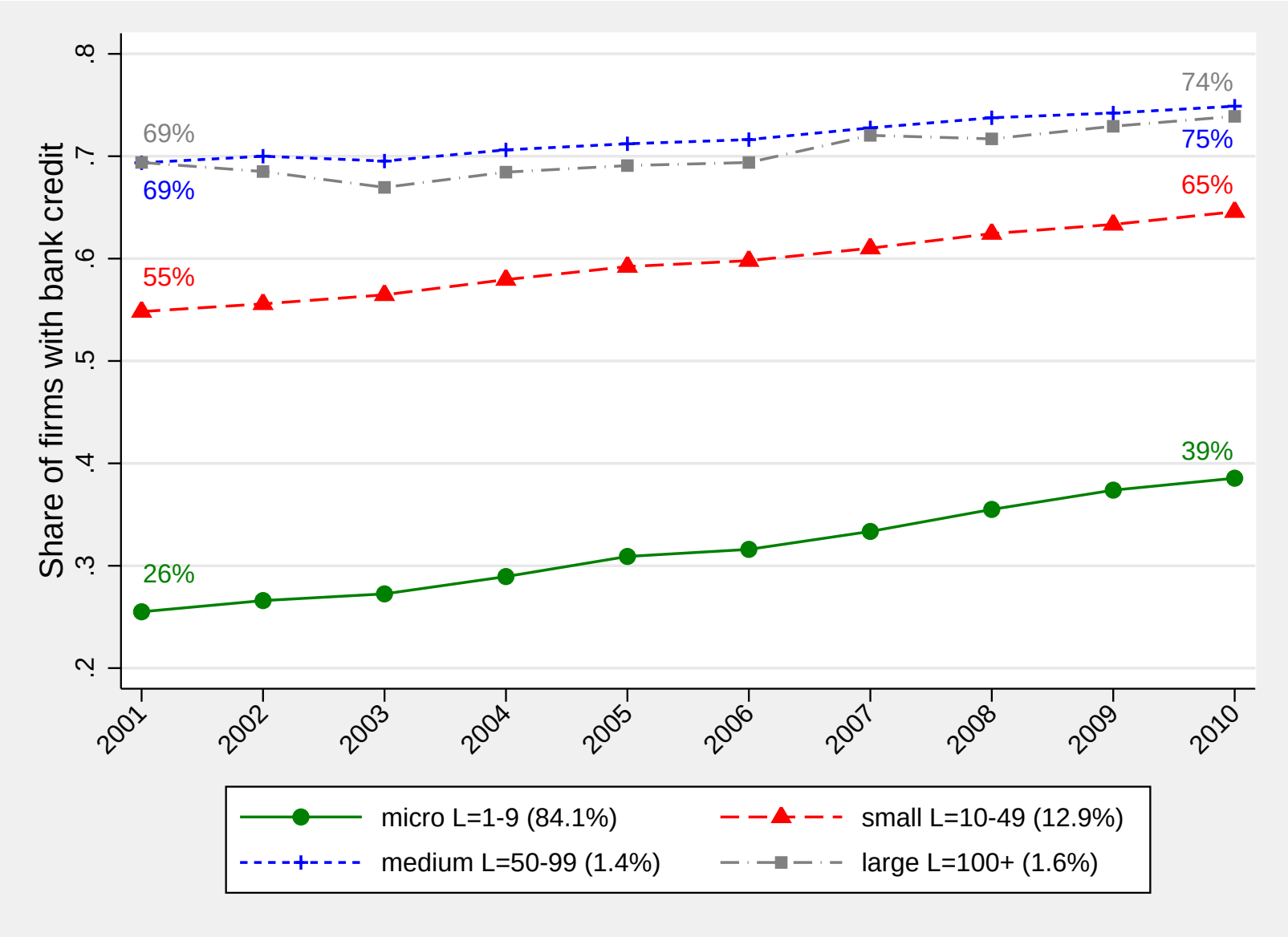
Brazil: 2001-2010



Source: Credit Information System of the BCB and RAIS, authors' calculation from micro-data. Services include: construction, commerce, lodging and restaurants, transport, housing services, domestic workers.

Share of Firms with Bank Credit: by Firm Size

Brazil: 2001-2010



Source: Credit Information System of the BCB and RAIS, authors' calculation from micro-data

back

Intensive margin

Heterogeneous Effects: by Sector and Number of Initial Lending Relationships

back