The Effects of Climate Change on Labor and Capital Reallocation: Evidence from Brazil

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- Our focus:
  - labor and capital reallocation across sectors/regions
  - spillover effects on destination regions

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- Track factor flows across sectors, regions and firms
  - → K: Bank branch balance-sheet data (ESTBAN)
  - → L: Census and social security data (RAIS)

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→ Explore mechanisms using firm-level exposure to climate migrants
- Manufacturing firms: (i) less connected to "drying" regions via migrant networks
  (ii) if connected, respond less to climate-driven L supply ↑

Related Literature

- Effects of weather shocks and long differences in climate on local economic activity and migration.

  [Jayachandran, 2006; Schlenker and Roberts 2006; Deschenes and Greenstone 2007; Dell et al. 2012; Hornbeck, 2012; Burke and Emerick, 2016; Henderson et al. 2017; Addoum et al., 2019; Colmer, 2021]

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- Quantitative trade and spatial models on long-run effects of climate change on allocation of economic activity

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→ Direct evidence based on past changes in climate can inform relevant margins of adjustment

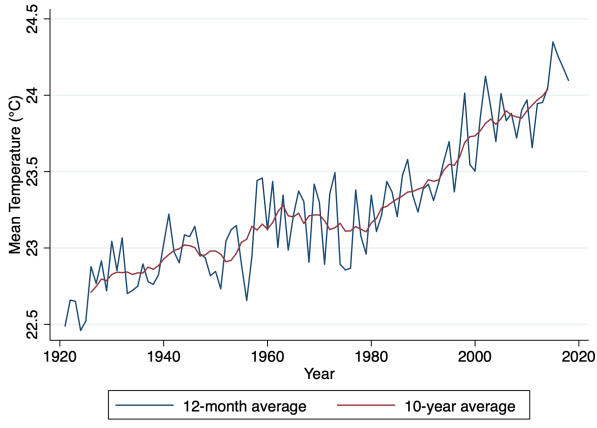
Structure of the Talk

1. Background, Data and Empirical Strategy
    - Climate change in Brazil
    - Natural disaster reports
    - Meteorological measure of excess dryness: SPEI
2. Results:
    - Agriculture
    - Direct and indirect effects on capital and labor markets
    - Firm-level evidence

Background, Data, and Empirical Strategy

Background: Climate Change in Brazil

Figure: Average temperature in Brazil since 1920

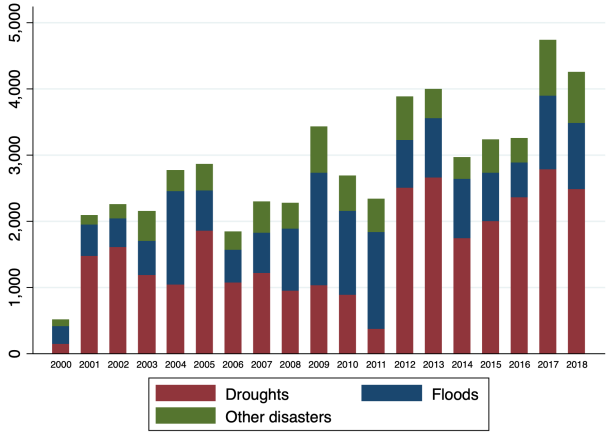


Notes: Data from Climatic Research Unit - University of East Anglia (`https://www.uea.ac.uk/groups-and-centres/climatic-research-unit`)

By macro-region

Data: Reports on Natural Disaster

- We digitized information contained in reports on natural disasters filed by Brazilian municipalities to the federal government



Notes: Data from Sistema Nacional de Proteção e Defesa Civil (SINPDEC)

Data: SPEI

- Challenges: potential reporting bias, short time span to measure climate change.
- Solution: measure of dryness based on meteorological variables
  [Vicente-Serrano et al. (2010)]

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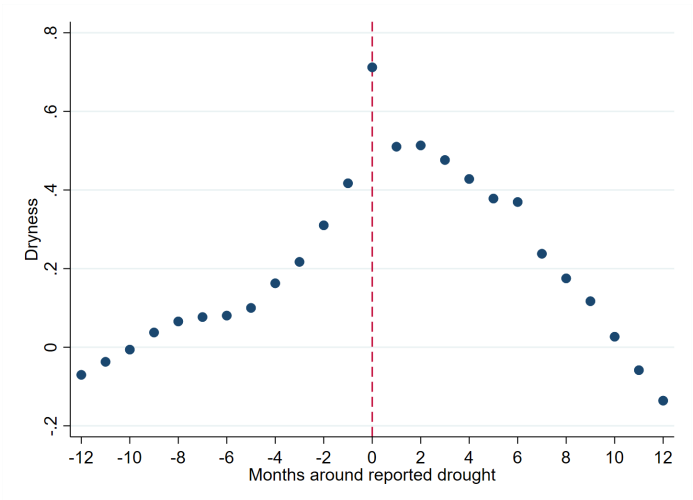
→ SPEI: Standardized Precipitation and Evapotranspiration Index

  - Measures standard deviations of dryness from long-term average (1905-2018)
  - Inputs: rainfall, temperature

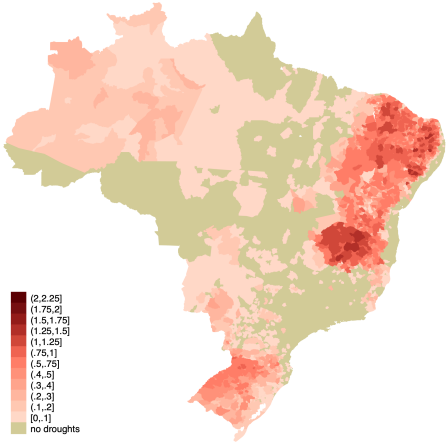
Dryness vs reported droughts

Figure: Average excess dryness index around drought events

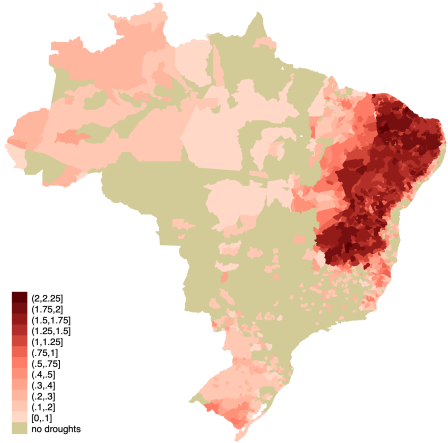


Reported Droughts

(a) 2000-2010

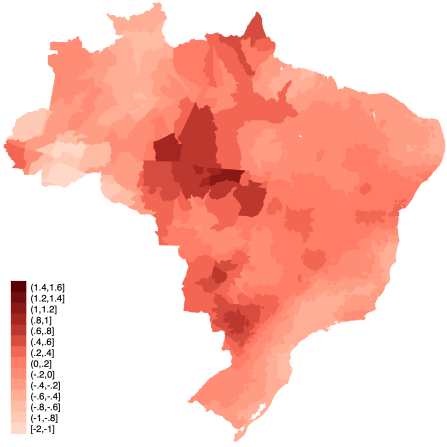


(b) 2011-2018

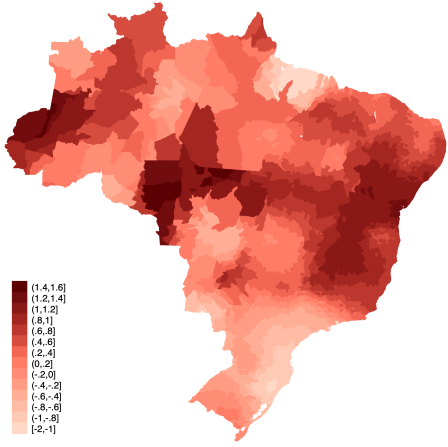


Dryness relative to historical average

(a) 2000-2010 "normal" decade



(b) 2011-2018 "dry" decade



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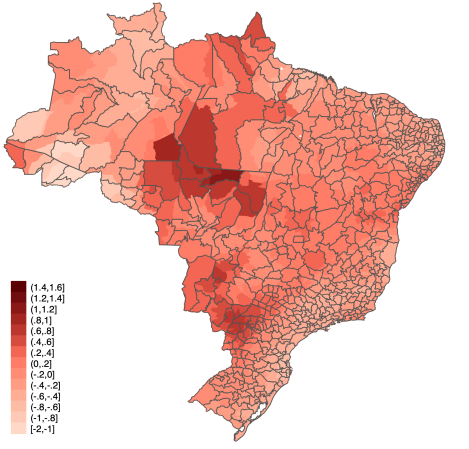

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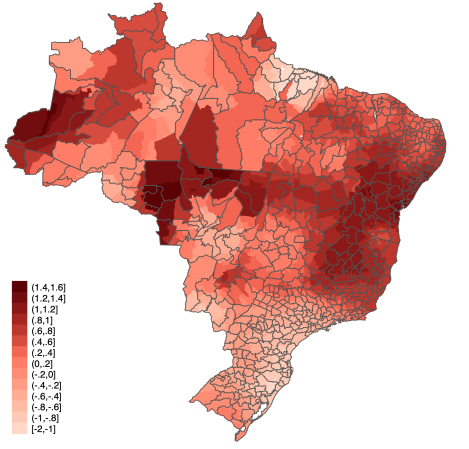
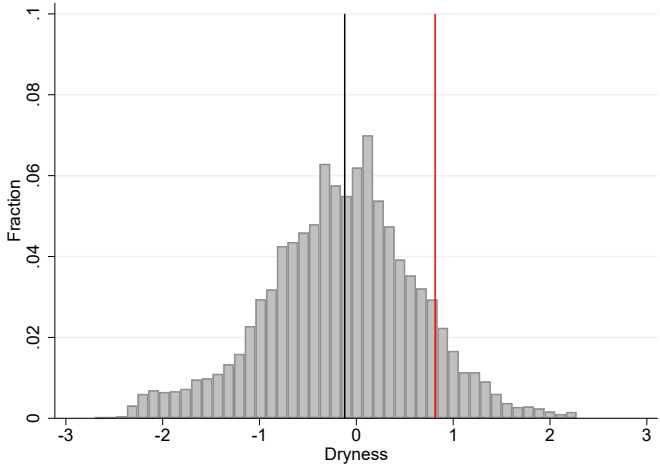


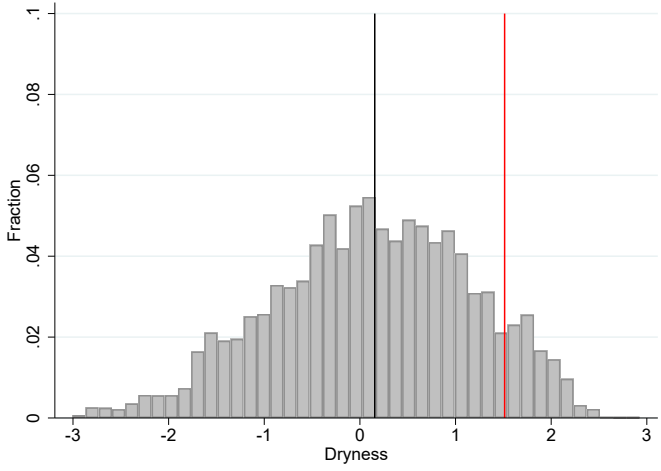
→ Standard errors clustered at micro-region level in all specifications

Distribution of Dryness: 2000 to 2010 ("normal" decade)



- municipality moving $50^{th} \rightarrow 90^{th}$ percentile of Dryness $\approx$ 1 St.Dev

Distribution of Dryness: 2011 to 2018 ("dry" decade)



- municipality moving $50^{th} \rightarrow 90^{th}$ percentile of Dryness $\approx$ 1.36 St.Dev First Stage

Balance test

	Number of reported droughts				
	1(# Droughts =0)	1(# Droughts > 0)	Difference		t-stat
share of rural population	0.387	0.536	0.148	***	7.50
log income per capita	4.719	4.309	-0.410	***	3.88
alphabetization rate	0.768	0.661	-0.107	***	3.13
soy soil suitability	0.271	0.334	0.064	***	2.86
maize soil suitability	0.859	1.132	0.272	***	4.31
	Dryness index				
	1(Dryness $\leq$ median)	1(Dryness > median)	Difference		t-stat
share of rural population	0.440	0.477	0.037		1.47
log income per capita	4.570	4.478	-0.092		0.93
alphabetization rate	0.734	0.700	-0.035		1.24
soy soil suitability	0.285	0.317	0.031		1.33
maize soil suitability	0.951	1.028	0.078		1.05

Notes: Observable characteristics observed in 1991 (pop census), except soy and maize productivity, which are theoretical soy and maize yields under low inputs as defined in Bustos, Caprettini and Ponticelli (2016).

Empirical Results

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1. Agriculture
2. Capital
3. Labor

Agriculture

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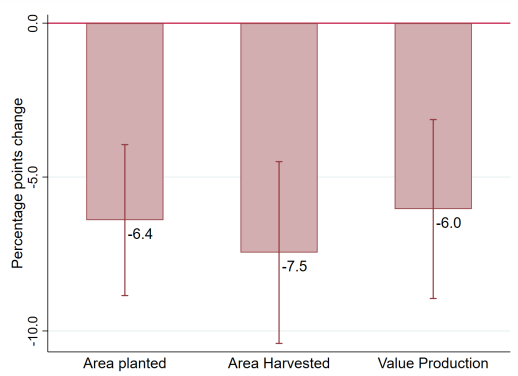
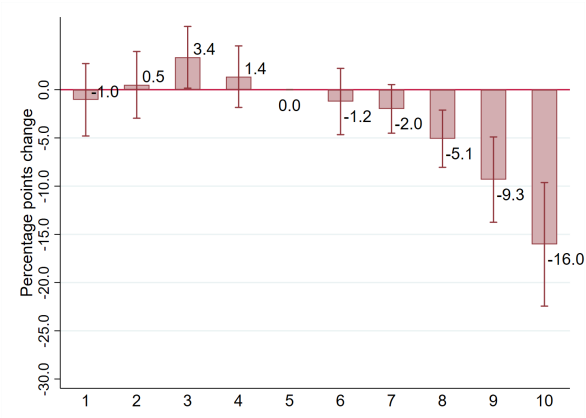
$$y_{mrt} = \alpha_m + \alpha_t + \alpha_{rt} + \beta Dryness_{mt} + \gamma X_{mrt} + u_{mrt}$$

m: municipality (4,248)
r: region (5)
t: time (2000-2018)



Notes: Effects for a municipality going from 50th→ 90th pct of *Dryness*.

Dryness and Value of Agricultural Production



Notes: Effects by decile of *Dryness* (wettest to driest), relative to 5th decile.

Area planted and harvested | Yields by Crop | Table

Capital

Capital: Specification

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- Outcomes: local loans, deposits, capital net flows (ESTBAN - Central Bank)

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- Steps to compute *ExposureDryness*:
  1. $$BankExposure_{bt} = \sum_{o \in O_b} \omega_{bo} Dryness_{ot}$$

O_b: set of origin municipalities o in which bank b was present at baseline
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$$ExposureDryness_{mt} = \sum_{b \in B_m} w_{bm} BankExposure_{bt}$$

B_m: set of banks operating in municipality m
w_{bm}: market share of bank b in m

Year-to-year effect of Dryness on Capital Outcomes

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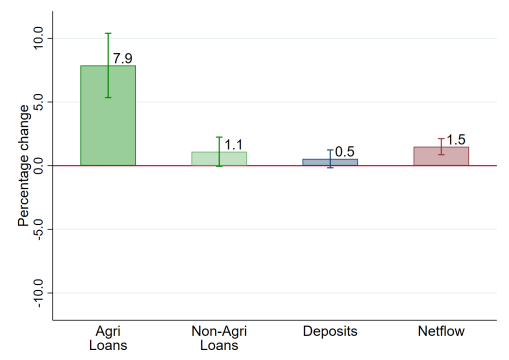

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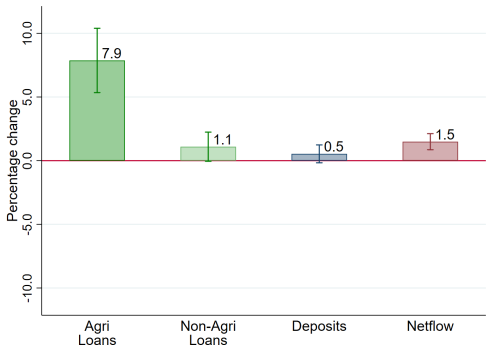

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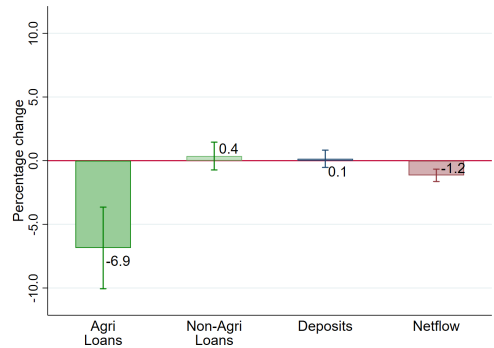

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Decadal effect of Dryness on Capital Outcomes

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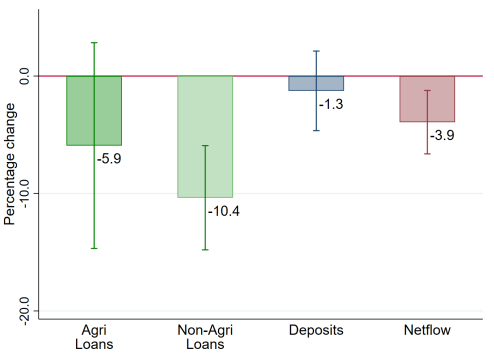

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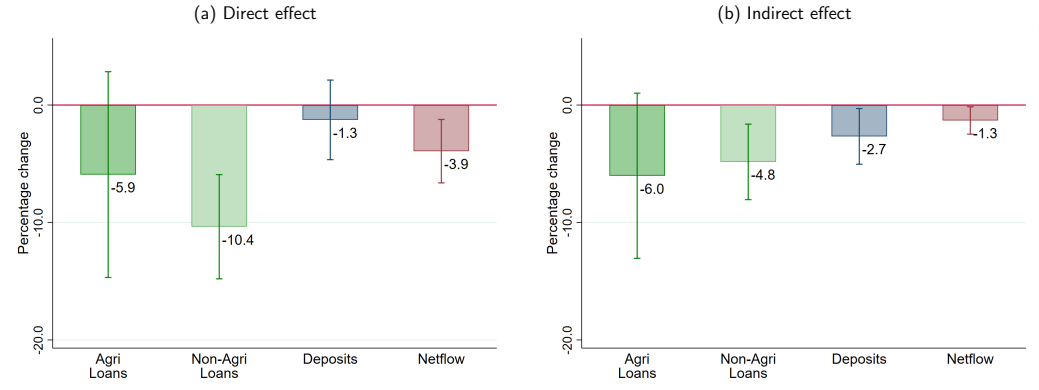

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Labor

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$$ExposureDryness_{m,2001-2010} = \sum_{o \neq m} \alpha_{om} Dryness_{o,2001-2010},$$

$$\alpha_{om} = \frac{\text{Migrants}_{o \to m}}{\text{Migrants}_{m}} \text{ in 2000 Census}$$

o: origin municipality, m: destination municipality

Migration

$$\left(\frac{inflow - outflow}{pop}\right)_{mr,2005-2010} = \alpha_r + \beta_1 \underbrace{Dryness_{m,2001-2010}}_{\text{Direct effect}} + \beta_2 \underbrace{ExposureDryness_{m,2001-2010}}_{\text{Indirect effect}} + \gamma X_{mr} + \varepsilon_{mr},$$

- Geographical correlation:
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- Control for exposure via trade linkages
  - Market access approach (Donaldson and Hornbeck, 2016)

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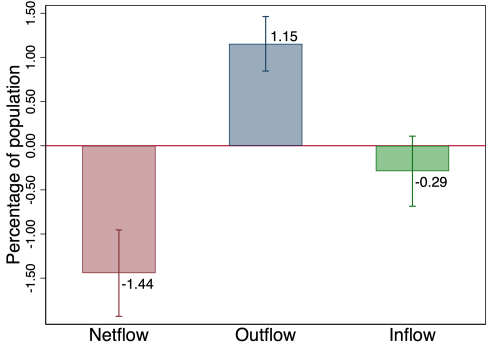

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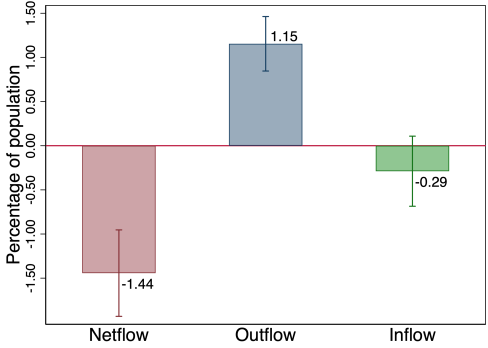
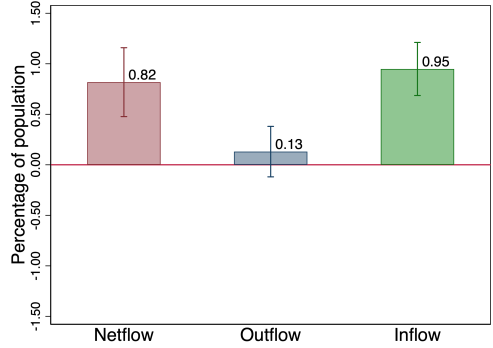


(b) Indirect effect

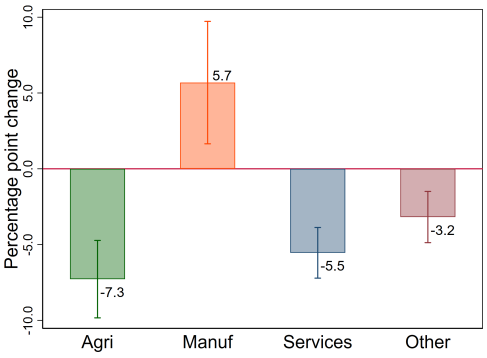


Sectoral structure of the economy

$$\Delta \log L^{sector}_{m,2000-2010} = \beta_1 \underbrace{Dryness_{m,2001-2010}}_{\text{Direct effect}} + \beta_2 \underbrace{ExposureDryness_{mr,2001-2010}}_{\text{Indirect effect}} + \alpha_r + \gamma X_{mr} + \varepsilon_{mr},$$

(a) Direct effect

(b) Indirect effect



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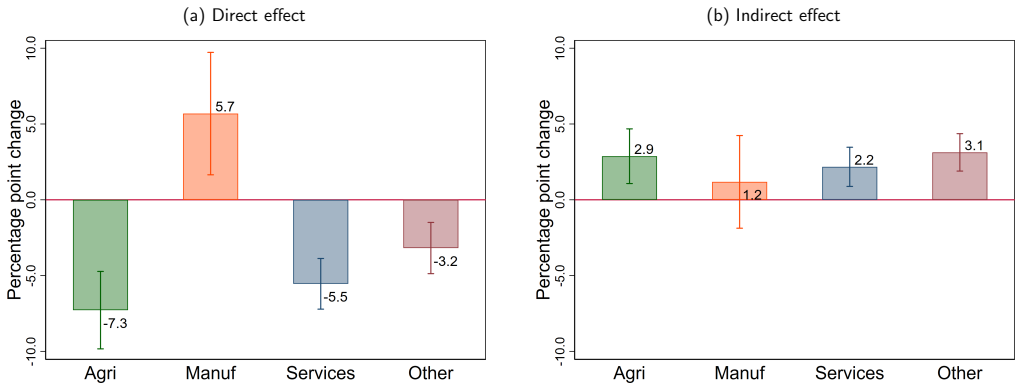

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Table: Decadal Effect of Dryness on Employment: 2000-2010

outcomes:	Δ log Employment						
sector:	all	all	all	agriculture	manufacturing	services	other
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Avg Dryness, 2001-2010	-0.0150**	-0.0278***	-0.0289***	-0.0728***	0.0570**	-0.0554***	-0.0318***
	(0.00708)	(0.00815)	(0.00817)	(0.0155)	(0.0246)	(0.0101)	(0.0103)
Exposure to Dryness via migrants		0.0192***	0.0210***	0.0287***	0.0118	0.0217***	0.0312***
		(0.00607)	(0.00609)	(0.0109)	(0.0185)	(0.00783)	(0.00748)
Exposure to Dryness via banks			-0.0134***	0.0139	-0.0940***	-0.00269	-0.0136**
			(0.00462)	(0.00891)	(0.0174)	(0.00619)	(0.00686)
Observations	4,248	4,248	4,248	4,248	4,241	4,248	4,248
R-squared	0.128	0.132	0.134	0.071	0.099	0.093	0.049
Macro-region FE	y	y	y	y	y	y	y
Controls	y	y	y	y	y	y	y

Notes: Standard errors clustered at the microregion level (558) reported in parenthesis. Coefficient estimates refer to a municipality moving from the 50th to the 90th percentile of the distribution of dryness or exposure to dryness. Controls include: the share of population living in rural areas, log income per capita, literacy rate, population density, changes in soy and maize potential yields and exposure to Dryness via trade links.

Correlation between measures of exposure | Table with exposure via trade coefficients

Margins of adjustment

- Effects for a municipality going from 50th→ 90th pct of *Dryness*

  → 3.7% of individuals aged 18-64 leave employment in agriculture and services.

  Of these:

  15% relocate locally to the manufacturing sector

  50% emigrate to other municipalities

- No direct/indirect effects on average wages Wages
  - Suggestive evidence that migrants from dry areas earn less than average worker at destination Individual-level results

Effects on Destination Firms

- Analysis at firm level:
  1. Explore mechanisms:
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To measure workers' flows across locations and firms we use data from RAIS:

- Employer-employee dataset, covering all formal workers

Firm exposure

- Firm exposure to past migration from municipality o:

$$\alpha_{oi(m)} = \frac{L_{i(m),o \to m}}{L_{i(m)}}$$

- Share of workers employed in firm i whose last move was $o \to m$

  (baseline year: 2005, reference period 1998 to 2005)

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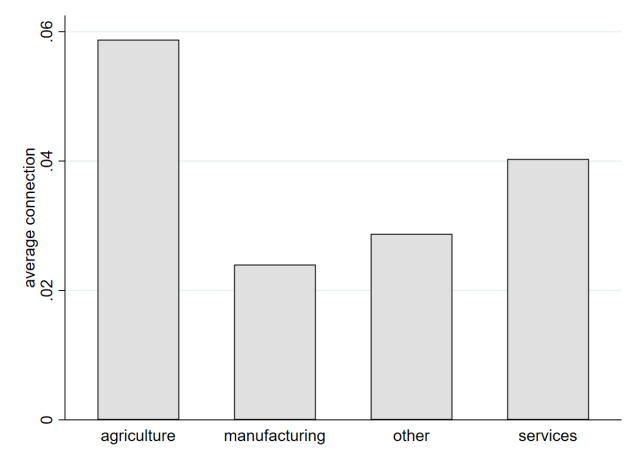
$\to$ Rationale: migrant workers follow similar employment trajectories as previous migrants from same area (e.g. referrals)

Firm-origin level specification

$$\underbrace{\frac{L_{oi(m),2006-2010}}{L_{i(m)}}}_{\substack{\text{worker flow}\\ \text{from origin } o\\ \text{to firm } i}} = \alpha_i + \beta_1 \alpha_{oi(m)} + \beta_2 \underbrace{\alpha_{oi(m)}}_{\substack{\text{firm initial}\\ \text{exposure to } o}} \times \underbrace{1(Dry)_o}_{\substack{=1 \text{ if } o\\ \text{top quartile}\\ \text{of } Dryness}} + \gamma 1(Dry)_o + \varepsilon_{oi(m)}$$

i: plant
m: destination municipality
o: origin municipality

Figure: Average firm-level initial connections to "very dry" municipalities



- Agriculture and services: more connected to drying regions via migrant networks
- Manufacturing: least connected

Firm exposure and employment growth

outcome:	(1) $\frac{L_{oi(m)2006-2010}}{Lavg_i}$	(2)	(3)
firm connection to origin $\times$ 1(*Dry*)		0.209***	0.322***
		(0.0560)	(0.0570)
firm connection to origin	0.621***	0.424***	0.506***
	(0.0189)	(0.0202)	(0.0271)
Observations	1,415,758	1,415,758	1,415,758
R-squared	0.257	0.356	0.663
mean Y	.13	.13	.13
destination AMC FE	y	y	y
firm FE	n	n	y

Notes: 1(*Dry*) included in all specifications. Standard errors clustered at meso-region (115) reported in parenthesis.

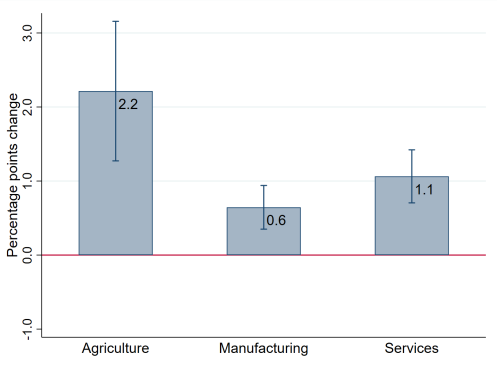
- Firms receive more migrant workers from regions with which initially connected
- This effect is larger for origins exposed to abnormal dryness
- Connections have larger effects when exploiting only *within-firm* variation: trade links might attenuate firm-level estimates

Reported droughts 2011-2017

Firm exposure and employment growth

- Effect for firms with average connection to areas with excess dryness, for 0.76 st.dev. ↑ *Dryness*

(a) by sector



(b) by size

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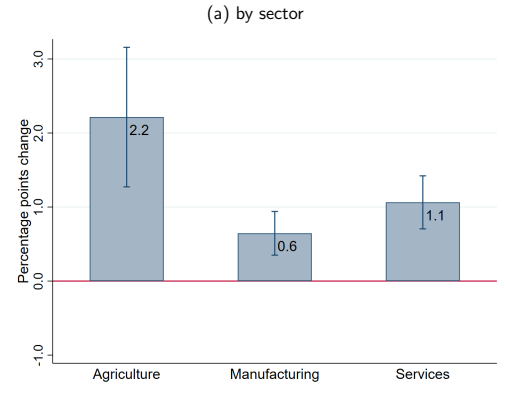

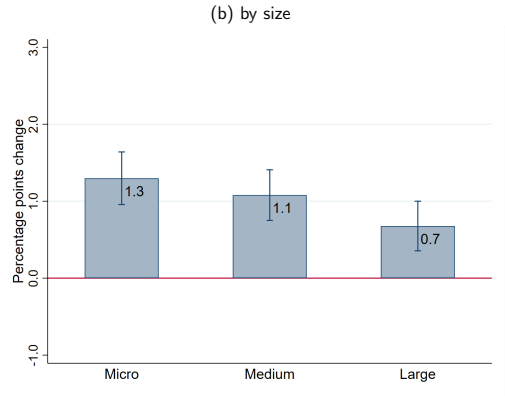

Concluding Remarks

- A full decade of excess dryness relative to historical averages generates:

  1. Reallocation of capital and labor away from affected regions

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     → Capital 3 to 4 times **more elastic** than labor to decadal changes in dryness

  2. Capital: short-run insurance vs long-run outflows

     → Negative spillovers on financially integrated regions

  3. Labor: net-outmigration, changes in the structure of the economy

     → Key friction: **spatial** reallocation from agriculture to manufacturing

Thank you!