The Origins of Structural Transformation

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The Origins of Structural Transformation

Economic Development ≈ Sectoral labor reallocation + Capital intensification

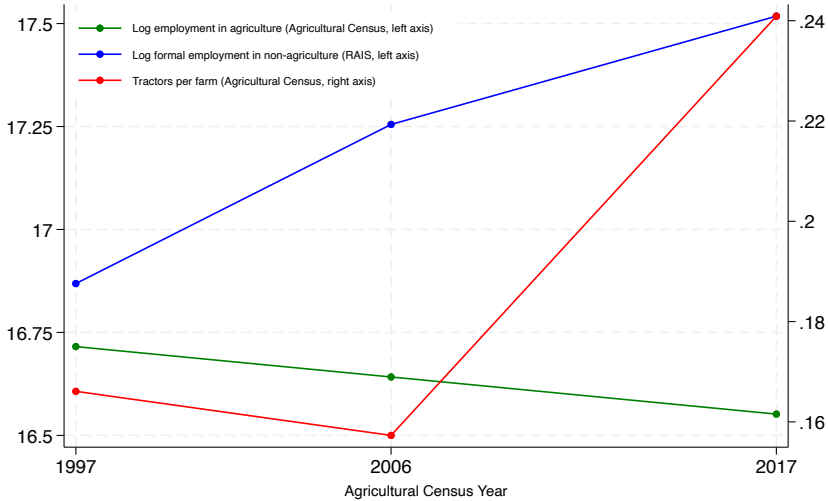
- In developing world, large share of labor employed in agriculture, but
  - low productivity
  - sluggish technology adoption
- Myriad of interventions and policy efforts in agriculture
- Can shocks originating in non-agriculture lead to structural transformation?

This paper: How do labor demand shocks in non-agriculture affect agriculture?

- Heterogeneity across development spectrum

Context: Brazil 1997-2017 at the *Macro* Level...

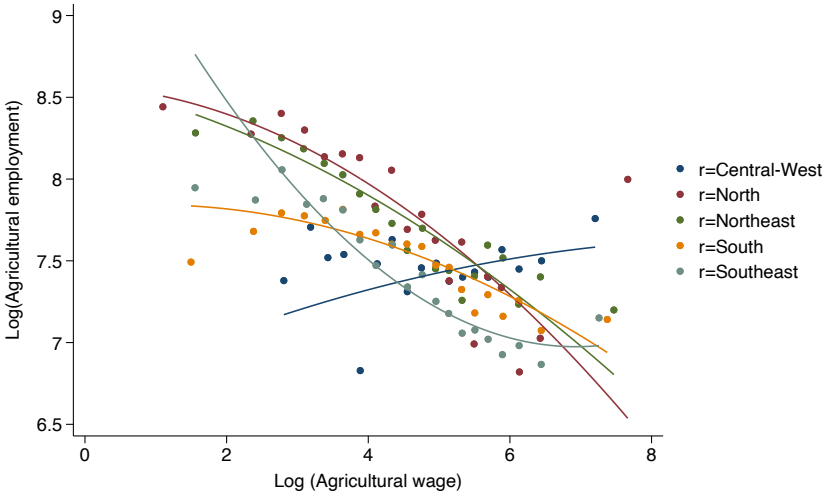
Decline in agricultural employment and tractor intensification



Pop Census

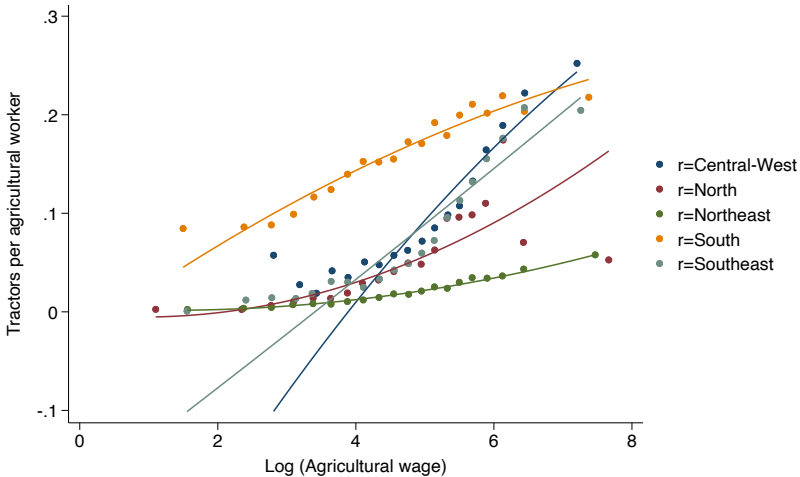
Context: Brazil 1997-2017 at the *Micro* Level...

Agricultural employment decreases in agricultural wages



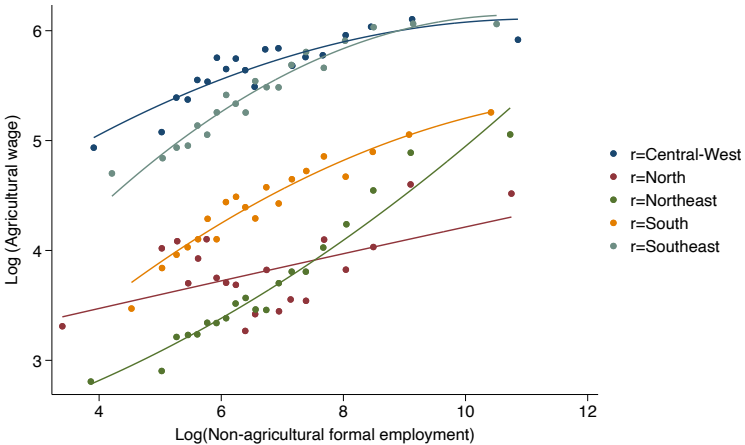
Context: Brazil 1997-2017 at the *Micro* Level...

Tractor intensity increases in agricultural wages



Context: Brazil 1997-2017 at the *Micro* Level...

Agricultural wages increase in non-ag employment



non-ag emp & non-ag wage

How do Labor Shocks in Non-agriculture Affect Agriculture?

1. **Model**. Multi-sector + firm/farm heterogeneity + endog. mechanization
   - Endogenous firm entry + selection
   - Endogenous farm size
   - Technology adoption/capital intensification

2. **Data**. Large non-ag firm entries in Brazil: DD & IV evidence
   - Employer-employee data + AgCensus, PopCensus, Crop-muni Production
   - Labor markets: Wages, skills and emp in Ag & Non-Ag
   - Organization of agriculture: Mechanization, land consolidation, output

3. **Quantification**. Ultimate goal: policy counterfactuals
   - Data $\Rightarrow$ Model: (lower) entry costs to target Δ wage (steady state)
   - Heterogeneity in outcomes: initial level of capital intensity in agriculture
   - [Not Today] Transition paths

Contributions

1. Study the *micro* mechanisms of structural change, in the aggregate...
   - Push-pull effects Schultz, '53; Gollin et.al., '07; Kuznetz '66; Caselli, '08; Alv.-Cuadrado & Poshke, '11.
   - Input intensification responds to relative prices Boppart et. al., '24; Caunedo & Keller, '24.

2. Role of shifts in relative *input* prices
   - Capital intensification in agriculture Manuelli & Seshadri, '14, Chen, '22..
   - Changes in land organization Adamopoulus & Restuccia, '14.
   - Intermediate inputs Donovan, '20.

3. **Big-picture**: Can the "puzzle" of sluggish technology adoption in agriculture reside elsewhere in the economy? Sury & Udry, '22; Udry '24 Kuznetz lecture.

Model

Environment

- Discrete time, infinite horizon
- Multiple sectors: non-agriculture, agriculture (calib. services/informality)
- Identical households and $\bar{N}$ time endowment
- Land in fixed supply
- Complete markets; Stone-Geary preferences $U(c_a, c_n, c_s; \bar{c}_a, \bar{c}_s)$

Key departures from canonical structural change models
(e.g., Ngai and Pissarides '07; Herrendorf, Rogerson, Valentinyi '14)

- *Endogenous mechanization*
  - Agricultural labor-capital ratio responds to relative input prices
  - Mechanization requires incurring fixed-costs
- Heterogeneously productive firms and farms/ w free-entry

Firms in Non-agriculture

- Production technology

$$Y_{n_i} = Z_{n_i} N_{n_i}^{\alpha} \qquad \alpha < 1$$

  - Productivity Z_{n_i} drawn upon entry from $G_n(Z)$
  - Fixed cost upon entry F_n
  - Operating cost f_n each period

Farms

- Production technology

$$Y_{a_j} = Z_{a_j} \mathcal{A}(\beta) \left(K_j^{1-\beta} N_{a_j}^{\beta} \right)^{\gamma} L_j^{\gamma_L}, \qquad \text{for } \gamma + \gamma_L < 1$$

  - Productivity Z_{a_j} drawn upon entry from $G_a(Z)$
  - Fixed cost upon entry F_a
  - Operating cost f_a each period
  - Key feature: endogenous mechanization, labor share β

Farm Mechanization

- Farming is a collection of activities $x(b)$

$$Y_{a_j} = Z_{a_j} \left(e^{\int_{b=0}^{1} \ln x(b)} \right)^{\gamma} L_j^{\gamma_L}$$

for $\frac{a_n(b)}{a_k(b)}$ continuously differentiable and decreasing in b

- Technology per activity
  - $x(b) = a_n(b) n_j(b) + a_k(b) k_j(b)$ if $b \in [\hat{\beta}, 1]$,
  - $x(b) = a_n(b) n_j(b)$ if $b \in [0, \hat{\beta})$.

- Farmers choose:
  - Set of technologies mechanizable, $\hat{\beta}$ with fixed cost I_β
  - Activities to perform with labor and with capital, $\beta \in [\hat{\beta}, 1]$

Farm Mechanization

- Optimal $\hat{\beta}$

$$p_x(b)a_k(b)k_i - rk_i > I \quad \rightarrow p_x(b)a_k(b) - r > \frac{I}{k_i}$$

Desired mechanizable activities,

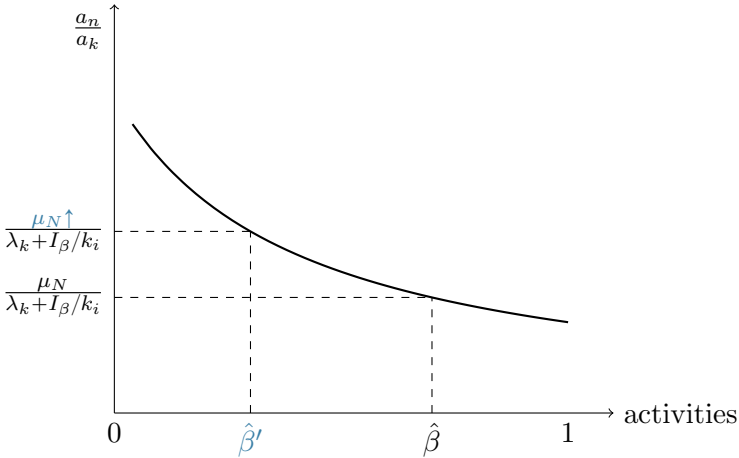
$$\frac{a_n(\hat{\beta})}{a_k(\hat{\beta})} = \frac{\mu_N}{\lambda_k + \frac{I_\beta}{k_i}}, \qquad \text{for } k_i = \frac{K_i}{1-\beta}.$$

$\uparrow \mu_N$ induces more mechanization, $\downarrow \hat{\beta}$

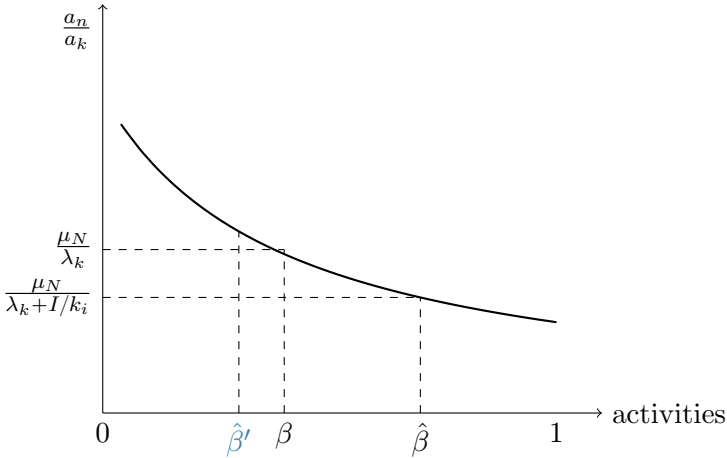
- Optimality: cutoff activity $\beta = b$ to be performed with labor

$$\frac{\mu_N}{\lambda_k} \geqslant \frac{a_n(\beta)}{a_k(\beta)} \qquad \text{w/inequality if } \beta \leqslant \hat{\beta}$$

Farm Mechanization



Farm Mechanization



Equilibrium Characterization

$\bar{c} = 0$ (homotheticity) equilibrium planner

- Non-agriculture employment

$$M_n^\star N_n^\star = \frac{N^p}{1 + (1-s) + \left(\frac{\gamma\beta}{\alpha}\right)\frac{\theta_n}{\theta_a}(1-s)}$$

for $s \equiv X/(M_n Y_n)$ the investment rate,

  - Benchmark (fixed β):
    Entry in **non-ag** $\uparrow M_n$ average firm employment, $N_n^\star \downarrow$ and $M_n N_n$ is constant
  - But... $\beta \downarrow$ when labor costs raise, $N_n^\star \uparrow$ (for any M)

- Free entry non-ag

$$M_n^\star = \frac{\theta_n(1-\alpha)}{\frac{\hat{\delta}}{\nu}\underbrace{F_n}_{\text{shock}}\mu_N}(1 - G(\underbrace{\underline{Z}_n}_{\text{selection}}))$$

Equilibrium Characterization

$\bar{c} = 0$ (homotheticity) equilibrium planner

- Agriculture employment

$$\frac{M_a^\star N_a^\star}{M_n^\star N_n^\star} = \frac{\gamma\beta}{\alpha} \downarrow \frac{\theta_a}{\theta_n}(1-s)$$

- Free entry

$$M_a^\star \downarrow = \frac{\theta_a(1-\alpha)}{\frac{\hat{\delta}}{\nu} F_a \underbrace{\mu_N}_{\text{labor mkt}}} (1 - \underbrace{G(\underline{Z}_a)}_{\text{selection}})$$

Evidence

Effect of Large Firm Entries in Non-agriculture on Agriculture

Example: Fortaleza (2014)

Firm: Construtora Colméia (local contractor)
Year: 2014
Event: Large-scale housing project launch
Target: Low-income HH; federal funding
Impact: New establishment → hundreds of local jobs

LISTA DE NOTÍCIAS

Mais de 22 mil unidades habitacionais serão construídas no Ceará

27 DE MARÇO DE 2014 - 09:07

A política habitacional é uma das prioridades do Governo do Estado, tanto que nesta quarta-feira (6) o governador Cid Gomes assinou junto a Caixa Econômica Federal o Programa de Financiamento de Contrapartidas do PAC (CPAC), no valor de R$ 120,4 milhões, que vai garantir a construção de 22.721 unidades habitacionais em todo o Ceará. Das unidades que serão subsidiadas com o aporte, 10.474 mil já começam a ser construídas a partir de hoje, já que na ocasião foram assinadas ordens de serviço para construção de mais de seis mil casas e a retomada das obras de outras três mil unidades nos municípios de Fortaleza e Caucaia. A solenidade, realizada no Palácio da Abolição, contou com a presença do Ministro das Cidades, Gilberto Occhi, e do vice-presidente José Henrique.

Todas as unidades contarão com o montante de R$ 1,05 bilhão do Governo Federal, por meio do Programa Minha Casa Minha Vida (MCMV). "Esta ação vai dá um ritmo muito mais célere na partição do Ceará no Programa Minha Casa Minha Vida. Em um primeiro momento desse Programa o Ceará teve uma participação muito pequena, mas agora o Estado avaliou e está dando um aporte de uma forma mais justa, serão mais de R$ 1 bilhão por parte do Governado Federal e R$ 120 milhões por parte do Governo Estadual, isso vai fazer com que o Ceará tenha uma participação mais forte na redução do deficit habitacional", explicou Cid Gomes.

IMG 3186

A construção de 6.698 novas unidades habitacionais beneficiarão os municípios de Crateús (795 unidades habitacionais); Maracanaú. (272); Canindé (495), Crato (1.578), Maranguape (294) e Fortaleza (3.264). Além disso foi autorizada a retomada das obras de 3.776 unidades, em Caucaia (2.656 casas) e Fortaleza (1.120), do MCMV I em que o Estado não era autorizado a entrar com aporte financeiro. "O Ceará tem se destacado, dado uma importante demonstração para o Programa Minha Casa Minha Vida. Um ato diz mais do que palavras e nós estamos aqui hoje não estamos falando, estamos fazendo. Está de parabéns o povo cearense que mostrou ser capaz de lutar pelo seu direito de ter uma moradia digna", destacou o Ministro Gilberto Occhi. Ainda segundo o gestor, o Ceará é referência no Programa e já conta com mais de 100 mil unidades habitacionais contratadas.

Effect of Large Firm Entries in Non-agriculture on Agriculture

New establishment:
≈300+ on-site workers at launch

Immediate effect:
Local hiring surge in construction

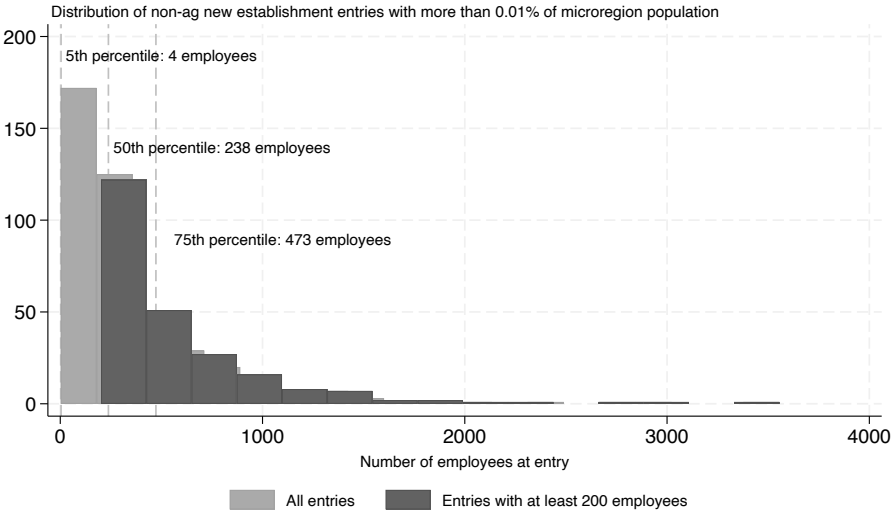
Effect of Large Firm Entries in Non-agriculture on Agriculture

Empirical strategy data

- **Large firm entry shock**
  chance of moving wages?
- **Shock**: Firm entries of i) $\geqslant 0.01\%$ of MMC population ii) 200+ workers
  geography sector skill distribution

What is the Role of Large-firm Entries?

Shock distribution



What is the Role of Large-firm Entries?

Empirical strategy data

- Compare municipalities with a large entry episode ("epicenter") with municipalities in never-entered micro-regions
  - RAIS and PAM outcomes (annual) levels
  - AgCensus outcomes (decade): for *today*, surroundings vs epicenter dist means
- (Promising) **Instrument**: Minha Casa Minha Vida (MCMV) about first stage

Regression Specification for Annual Outcomes

RAIS and PAM

Epicenter: *municipality with an episode of "entry" for a new establishment*

$$y_{mt} = \sum_{k=-5, k\neq 0}^{k=10} \beta_k \left[\text{Epicenter}_m \times (1_{k=t-t^*_m+1})\right] + \delta_t + \delta_m + \epsilon_{mt}$$

t^*_m is municipality m's large entry year;

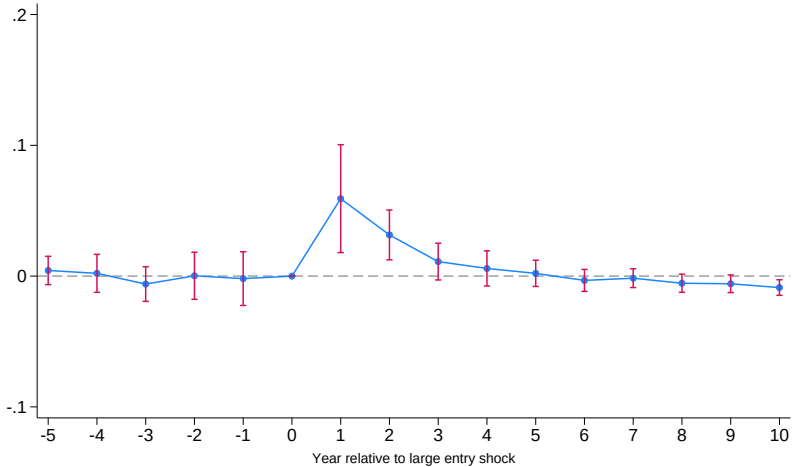
y_{mt} is municipality outcome at year t.

Staggered DD specification (Chaisemartin and d'Haultfoeuille '20)
→ Sample: All epicenters and all munis in never-entered micro-regions
→ Control: Municipalities in never-entered micro-regions

Graphs Today: Per-period effects

A Large Non-ag Entry... Increases Non-ag Real Wages

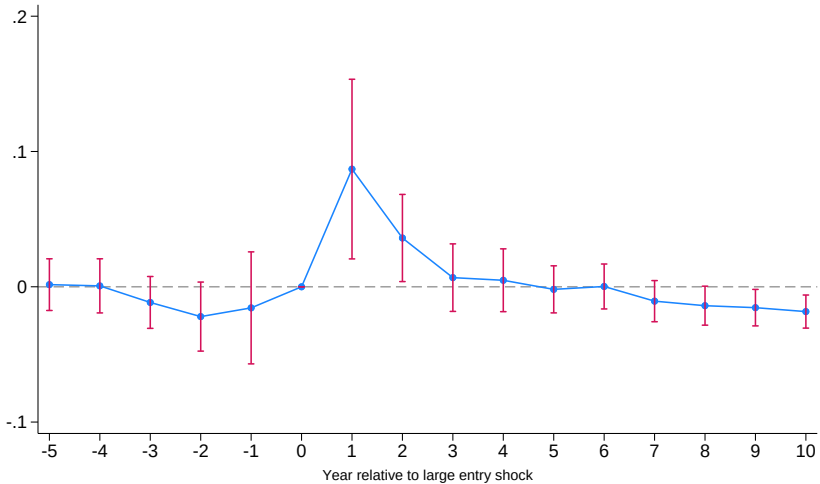
Cumulative effect 10 years out: $\Delta\mu_N = 1.4\%$



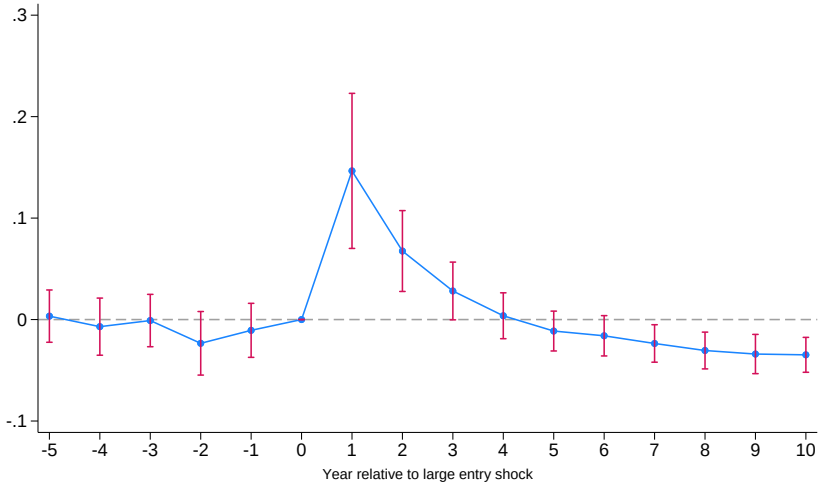
Ag vs. Non-ag

... and These Effects are Orthogonal to the Soy ("push") Boom

Effects dropping areas ever producing soy in 1973-2017

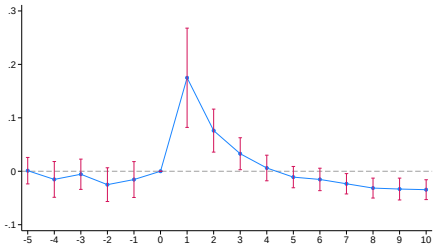


A Large Non-ag Entry... Increases *Total* Formal Employment

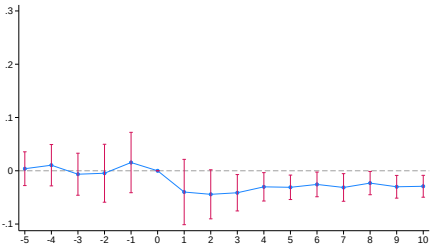


by education | tradable vs non-tradable | construction

A Large Non-ag Entry... Decreases *Agriculture* Formal Employment



(a) Non-Agriculture



(b) Agriculture

area planted increases

Regression Specification for AgCensus Outcomes (Cecadal)

1. Epicenter: *municipality with a large-entry event*

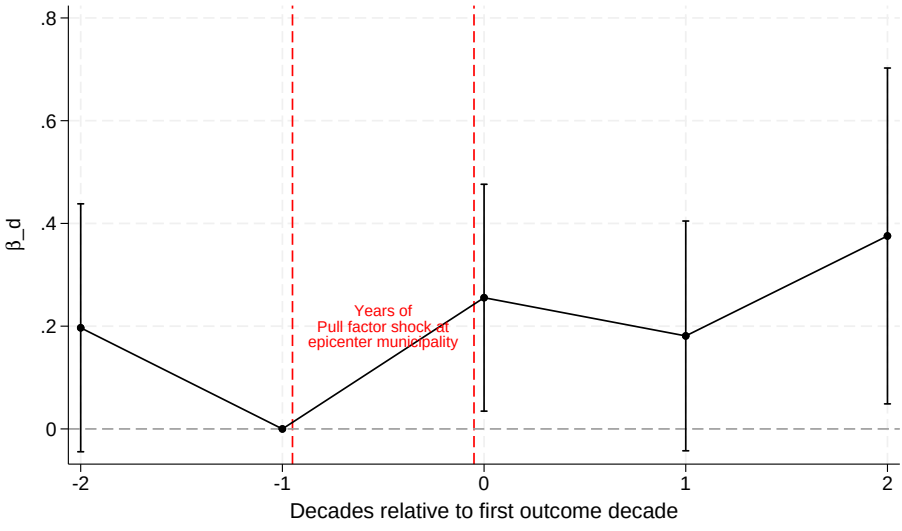
2. Surroundings: *surrounding municipalities in the epicenter's a micro-region*

$$y_{mt} = \sum_{d=-2, d\neq -1}^{2} \beta_d \left[\text{Surrounding}_m \times (t_m^* \in \Theta_d)\right] + \delta_d + \delta_t + \delta_m + \epsilon_{mt}$$

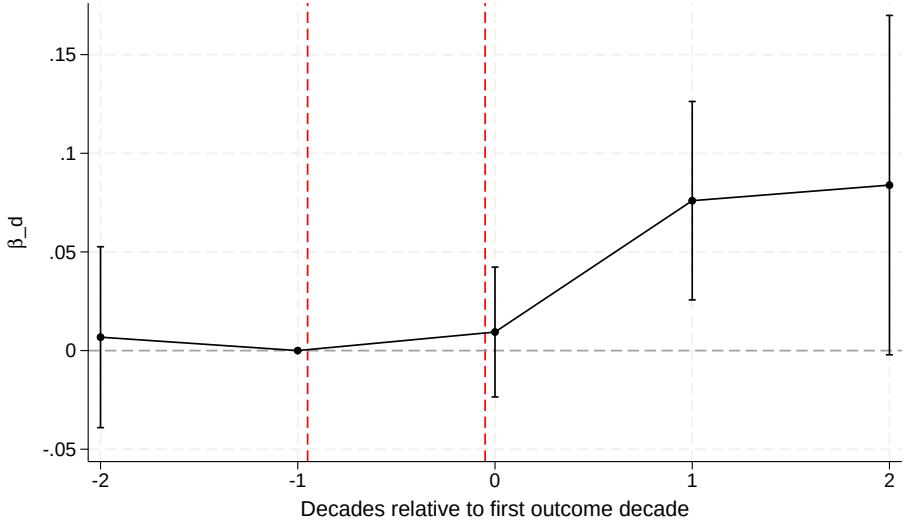
Θ_d is decade set of years in-between AgCensus years (1997, 2006, 2017);
t_m^* is year of microregion's first large entry;
y_{mt} is municipality outcome on AgCensus year t.

Staggered DD specification (TWFE, given few AgCensus years)
→ Sample: All micro-regions with epicenters
→ [For today] effects relative to epicenter

A Large Non-ag Entry... Increases Real Wages in Agriculture



A Large Non-ag Entry... Increases Tractors per Hectare



Effect of Non-Ag Large Entry on Organization of Agriculture

	Log wage	Log workers	Log tractors/farm	Log small farms
Sur X Post	0.303**	-0.307**	0.0544*	-0.351**
	(0.136)	(0.146)	(0.0279)	(0.144)
Sur X Post X Base Tractors/farm	-0.0512	0.138**	0.101***	0.00634
	(0.0951)	(0.0683)	(0.0356)	(0.159)
Sur X Post X Entry Size	-0.0000586	0.0000475	-0.0000358**	0.000111***
	(0.0000477)	(0.0000291)	(0.0000144)	(0.0000412)
Observations	2087	2092	2087	2092

Summary

Entry of large establishments in non-agriculture induces...

1. increase in wages
2. lower employment in agriculture relative to non-agriculture
3. mechanization, more tractors per acre/farm
4. less employment in agriculture
5. land consolidation/exit of small farms

Robustness: different cut-off, inclusion of soy, estimator...

Model Quantification

Quantitative Exploration

1. Parameterize the economy to a steady state in 1997 direct calibration
2. "Large-entry" counterfactual = change entry costs in non-agr. to match $\Delta\mu_N$
3. Explore implications for
   - Employment
   - Farm size
   - Mechanization

   ...comparative statics *with* and *without* mechanization
4. Heterogeneity? Some...

Bringing Model to the Data

Moments			Model Parameters		
Description	Target	Model	Var.	Value	Description
Share of non-ag firms with above average empl.	12.3%	12.5%	α_n	6.8	Productivity distr. non-agr., tail parameter
Share of farms larger than 100 ha	10.7%	9.6%	α_a	9	Productivity distr. agr., tail parameter
Average land per farm (ha)	72.7	73.7	L	180	Total land endowment
Share of labor in agriculture	15.8%	15.4%	$\bar{N}$	70	Total labor endowment
Labor productivity in agr. to non-agr.	0.25	0.28	F_a	0.6	Entry cost in agriculture
Capital to output ratio in agriculture	2.17	2.14	β	0.85	Share of labor within composite

+ homothetic preferences and informality/service sector production technology in s

Bringing Model to the Data

Moments			Model Parameters		
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Share of non-ag firms with above average empl.	12.3%	12.5%	α_n	6.8	Productivity distr. non-agr., tail parameter
Share of farms larger than 100 ha	10.7%	9.6%	α_a	9	Productivity distr. agr., tail parameter
Average land per farm (ha)	72.7	73.7	L	180	Total land endowment
Share of labor in agriculture	15.8%	15.4%	$\bar{N}$	70	Total labor endowment
Labor productivity in agr. to non-agr.	0.25	0.28	F_a	0.6	Entry cost in agriculture
Capital to output ratio in agriculture	2.17	2.14	β	0.85	Share of labor within composite

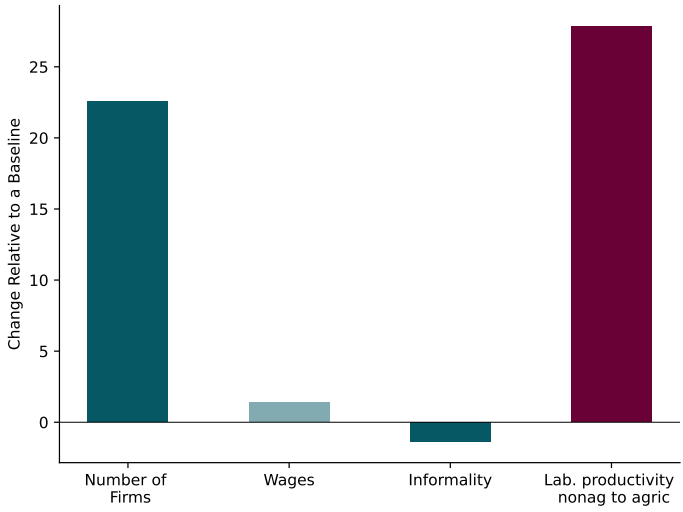
+ homothetic preferences and informality/service sector production technology in s

- Large entry counterfactual: $\downarrow F_n$ to target decadal $\Delta\mu_N = 1.4\%$

$$M_n^\star = \frac{\theta_n(1-\alpha)}{\frac{\hat{\delta}}{\nu}\underbrace{F_n}_{\text{shock}}\mu_N}(1 - G(\underbrace{Z_n}_{\text{selection}}))$$

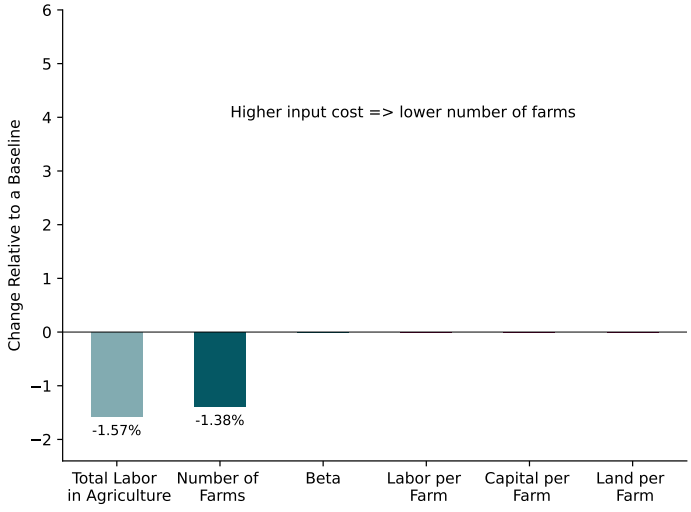
- Why $\downarrow F_n$: $\Uparrow$ non-ag/ag prod.; $\Uparrow$ entry average firms (mean firm size data 30)

Firm Entry Shock $\Downarrow F_n$: Non-agriculture

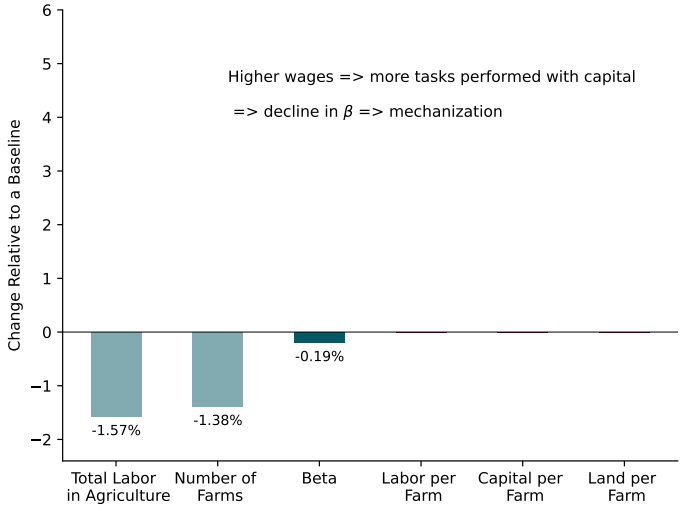


Firm Entry Shock $\Downarrow F_n$: Reduces Agricultural Labor

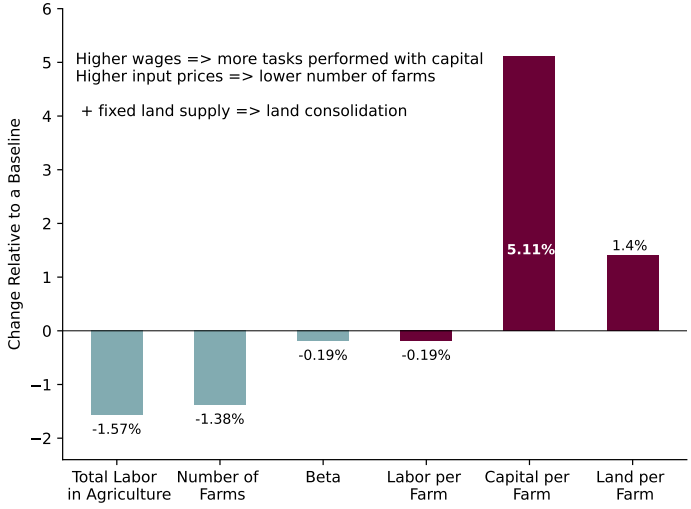
Firm Entry Shock $\Downarrow F_n$: Reduces the Number of Farms



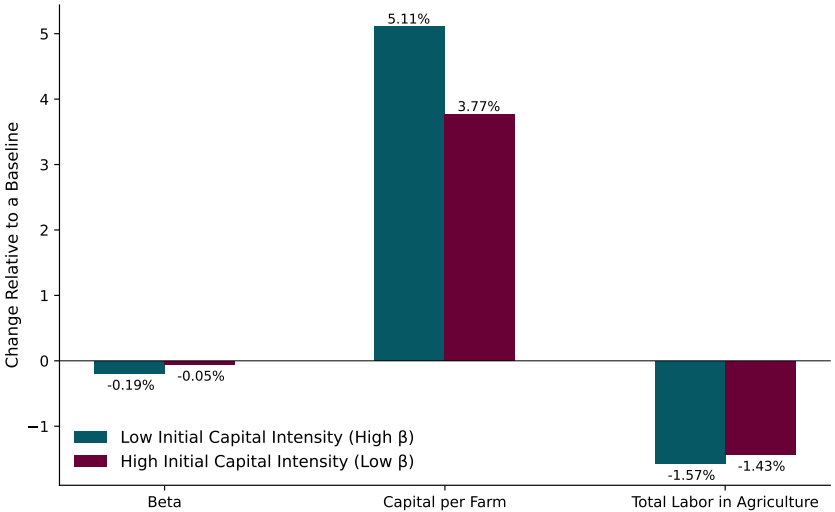
Firm Entry Shock $\Downarrow F_n$: Reduces Labor Intensity in Agriculture



Firm Entry Shock $\Downarrow F_n$: Reorganizes Agricultural Production



Effects are Larger at Lower Initial Capital Intensity



Taking Stock

Non-agriculture shocks can be powerful to reorganize agriculture

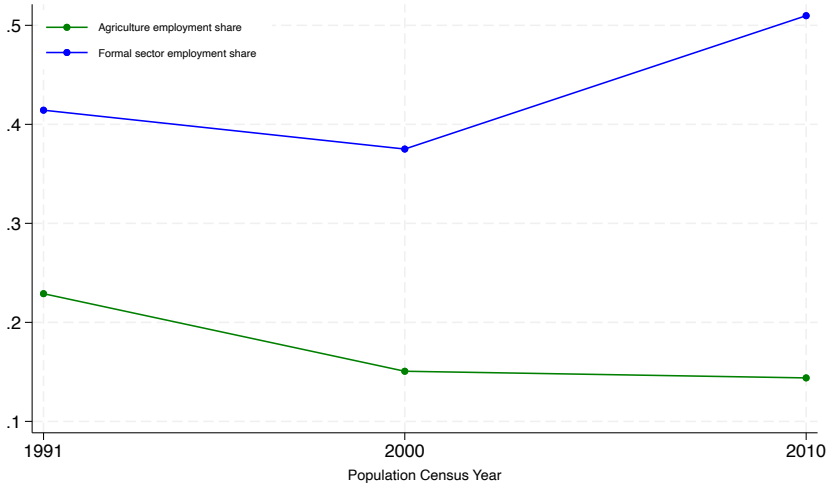
→ Capital intensification and land consolidation

In progress:

- Robustness of reduced-form results to IV design
- Effects on migration flows and non-ag informality
- Explore heterogeneity across regions in different stages of development
  - Reduced-form effects
  - Model quantification: Transition dynamics; Counterfactuals

Appendix

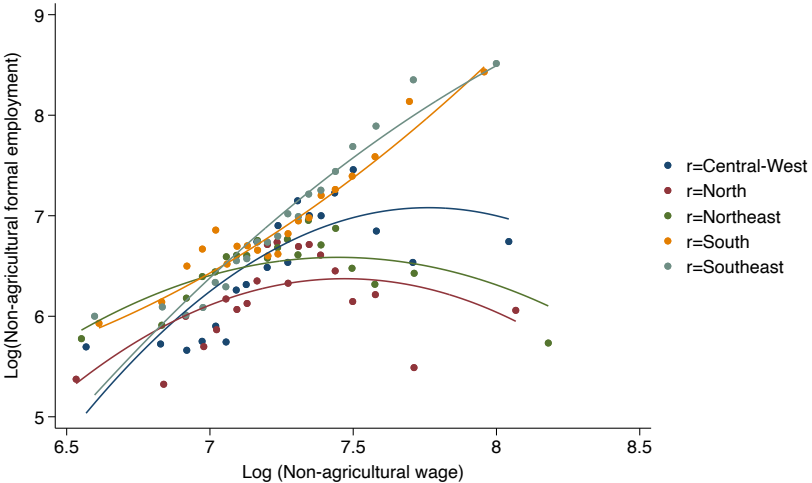
Structural Change: Brazil 1990s to Date



Back

Brazil 1997-2017: At the *micro* level... *local labor market* is key

Non-ag wages also increase in non-ag employment



Equilibrium

Definition

An equilibrium is an allocation $\{N_i, c_i\}_{i=a,n,s}$, measures of firms $\{M_i\}_{i=a,n}$ s.t. given, K_0, sectoral prices, λ_j, input costs μ_n and r, entry and fixed costs $\{F_i, f_i\}_{i=a,n}$

1. households maximize utility given their budget set,
2. firm maximize profits,
3. the markets for goods, capital, and labor clear,
4. the law of motion of firms and farms satisfy,

$$M_{it+1} = m_{it}(1 - G(\underline{Z_{it+1}})) + M_{it}(1 - \delta_{M_i}), \quad \text{for } i = a, n$$

5. free-entry is satisfied.

more

Equilibrium

Market clearing conditions:

- Labor

$$\overbrace{M_n N_n + M_a N_a + N_s}^{\text{productive}} + \overbrace{N^f}^{\text{costs}} = \bar{N}.$$

$$N^f \equiv F_a m_a + F_n m_n + M_a \int_{\underline{Z}_a}^{\infty} f_a g_a(Z) dZ + M_n \int_{\underline{Z}_n}^{\infty} f_n g_n(Z) dZ,$$

- Goods

$$C_a = M_a \int_{\underline{Z}_a}^{\infty} Y_{aj} g_a(Z_j) dZ_j = M_a Y_a, \qquad C_n + X_t = M_n \int_{\underline{Z}_n}^{\infty} Y_{ni} g_n(Z) dZ = M_n Y_n.$$

$$C_s = Y_s.$$

- Capital

$$M_a \int_{\underline{Z}_a}^{\infty} K_{jt} g_a(Z_j) dZ_j \equiv K_t. \qquad K_{t+1} = X_t + (1 - \delta_k) K_t.$$

back

Data

Data at the municipality level

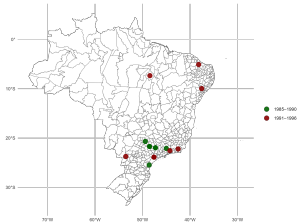
- Agricultural Census (1995-96, 2006, 2017)
  - Inputs of production: land, capital, labor.
  - Outputs.
  - Producer/farm characteristics.
- Employer-Employee Data (RAIS, 1985-2021)
  - Formal employment
  - Wages
  - Education
- *GDP and VA (2002-'20), exports and imports data (1997-2022)*
- Census for migration, wages, sectors (1991, 2000, 2010)

Municipalities linked into Micro-regions

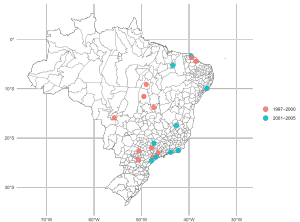
- Cross-walk microregions time (Kovac & Dix-Carneiro).

back

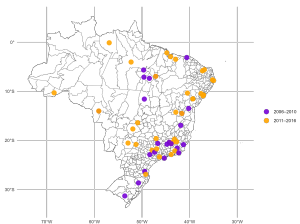
Spatial distribution of Large-firm Entries



(a) 1985-1996



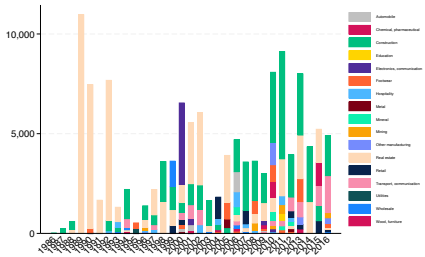
(b) 1997-2005



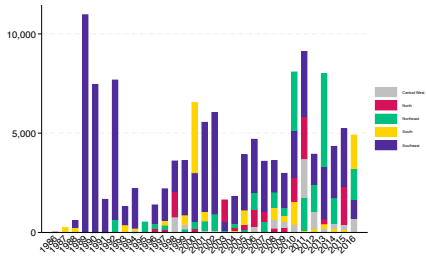
(c) 2006-2016

back

Sectoral and spatial distribution of Large-firm Entries



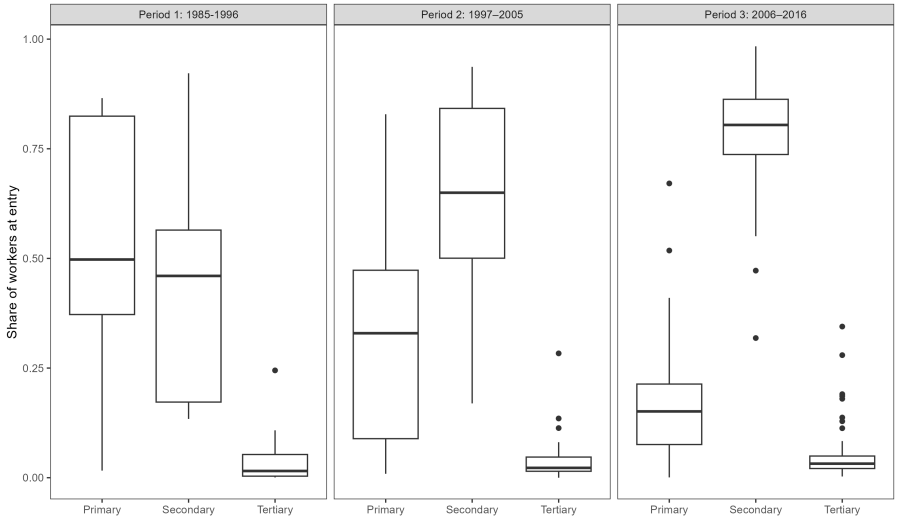
(a) By Industry



(b) By Region

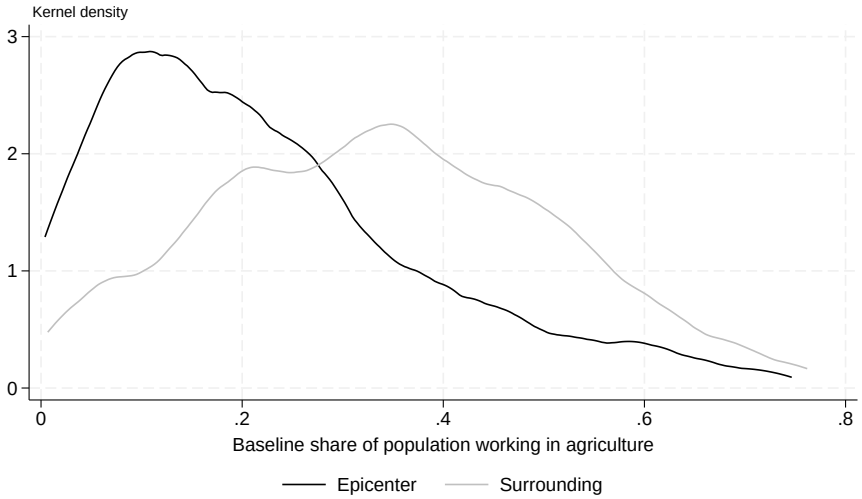
back

Skill composition of Large-firm Entries



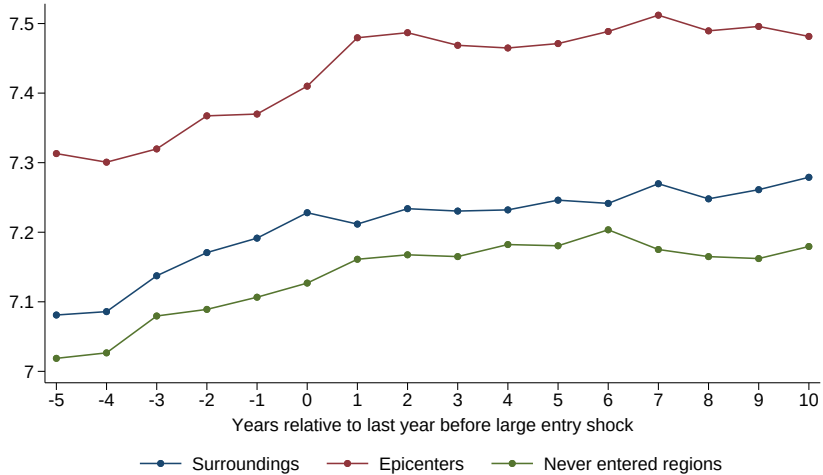
back

Employment in Agriculture: Epicenter town vs. Surrounding farms



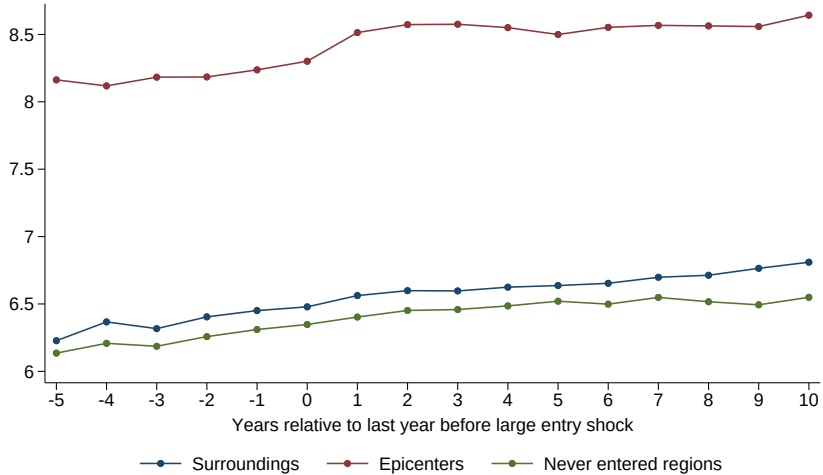
back

Levels: Non-agricultural Formal Real Wage



back

Levels: Total Non-agricultural Formal Employment



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Baseline Characteristics

	Epicenter (N=85)	Surrounding (N=609)	All (N=694)	P-value
Farmland (ha 000s)	133.14 (203.23)	93.54 (152.47)	98.39 (159.91)	0.032
# Farm workers	4246.34 (4279.88)	3080.90 (3130.91)	3223.64 (3311.61)	0.002
# Workers per farm	4.48 (3.70)	3.88 (2.44)	3.95 (2.63)	0.053
# Tractors per farm	0.34 (0.44)	0.30 (0.54)	0.30 (0.53)	0.566
Crop production (BR 100k)	16.78 (25.71)	9.43 (17.43)	10.33 (18.77)	<0.001
Any soy planted (PAM)	0.25 (0.43)	0.25 (0.43)	0.25 (0.43)	0.988
Formal non-ag employment (000s)	16.85 (46.43)	2.53 (6.41)	4.28 (17.87)	<0.001
Agricultural monthly wage (AgCensus, 2017 reais)	322.67 (514.31)	299.16 (1571.96)	301.95 (1486.10)	0.893
Non-ag. monthly wage (RAIS, 2017 reais)	1761.99 (699.30)	1493.41 (502.31)	1526.30 (537.04)	<0.001

back

Promising instrument: Minha Casa, Minha Vida (MCMV)

Largest housing construction program in Brazilian history

- **Federal housing program (2009–)**
  - Low-income housing w/ >6 million units contracted
  - Financed & coordinated federally ⇒ local fiscal capacity not a constraint
- **Project roll-out depended on:**
  - Federal targeting criteria (housing deficit)
  - Developer proposals meeting program rules
  - Availability of government-owned land (municipal, state, or federal)
  - **Simoni ('24):** Mayor political alignment in 2009 w/ federal ruling coalition predicts MCMV contracts for lowest-income housing units in 2009-2014 (presidential elections: 2010). We replicate.
- **IV strategy:**
  - Political alignment + admin. constraints ⇒ plausibly exogenous to agriculture
  - MCMV contracted housing units ⇒ Epicenter in construction / real estate

back

Promising Instrument: MCMV predicts large entry shocks

$$y_m = \alpha + \beta \text{MCMV} + \epsilon_m \tag{1}$$

	(1) Epicenter	(2) Construction Epicenter	(3) Real Estate Epicenter	(4) Formal Construction Employment	(5) Formal Real Estate Employment
MCMV	0.115***	0.042**	0.032***	2273.356***	1885.454**
	(0.022)	(0.021)	(0.006)	(362.822)	(753.275)
Constant	0.020	0.020	-0.000***	236.807**	1088.929*
	(0.019)	(0.019)	(0.000)	(99.484)	(595.951)
Observations	953	953	953	953	953

Note: Sample is all micro-regions with any epicenters in 2009-2014. MCMV is a dummy indicating any Minha Casa Minha Vida contracted housing units in 2009-2014. Columns (1)-(3) are dummies indicating if municipality m was an epicenter, and of which kind, anytime in 2009-2014. Columns (4)-(5) are total municipal formal sector employment for 2009-2014. Robust standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

unrelated to soy back

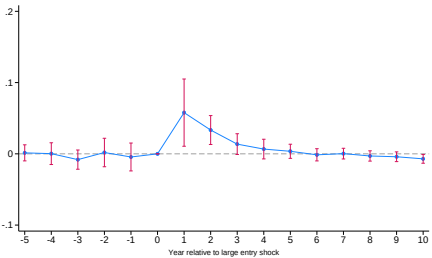
MCMV-driven housing demand unrelated to soy production

$$y_m = \alpha + \beta \text{MCMV} + \beta[\text{Muni produced any soy in 1985-2017}] + \epsilon_m \qquad (2)$$

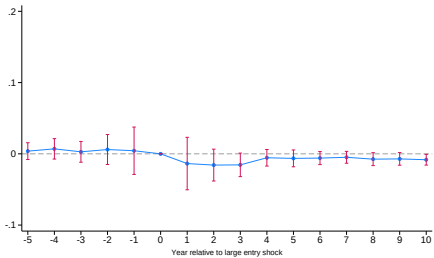
	(1) Epicenter	(2) Construction Epicenter	(3) Real Estate Epicenter	(4) Formal Construction Employment	(5) Formal Real Estate Employment
MCMV	0.114***	0.048**	0.025***	2372.029***	2036.157**
	(0.023)	(0.021)	(0.005)	(415.723)	(798.959)
Any soy 1985-2017	0.002	-0.026*	0.032***	-441.938	-674.974
	(0.022)	(0.015)	(0.011)	(667.080)	(881.205)
Constant	0.019	0.027	-0.009**	358.123*	1274.216**
	(0.021)	(0.020)	(0.004)	(208.540)	(647.270)
Observations	953	953	953	953	953

back

RAIS: Employment increases in non-ag; decreases in agriculture



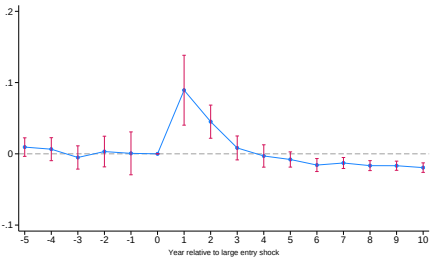
(a) Non-Agriculture



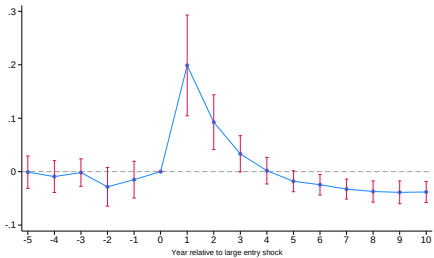
(b) Agriculture

back

Employment and wages in epicenter: (some) primary education



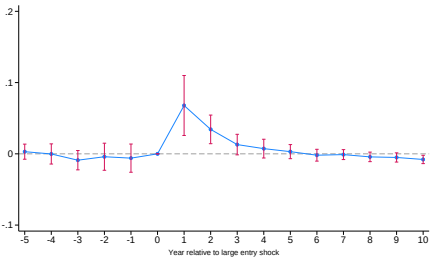
(a) Average Wage (log)



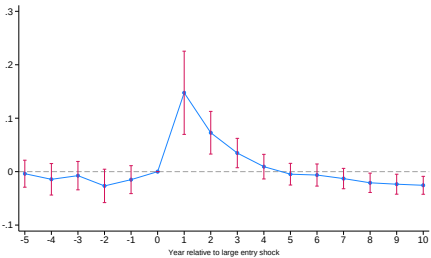
(b) Employment (log)

back

Employment and wages in epicenter: (some) secondary education



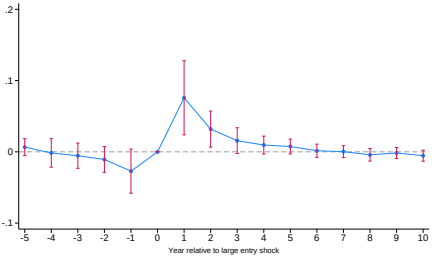
(a) Average Wage (log)



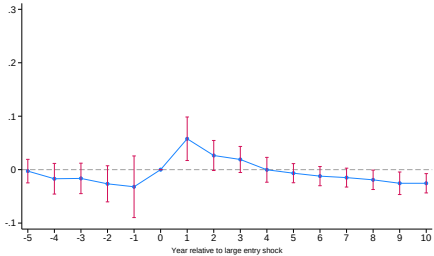
(b) Employment (log)

back

Employment and wages in epicenter: (some) tertiary education



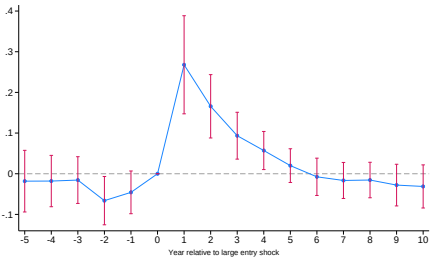
(a) Average Wage (log)



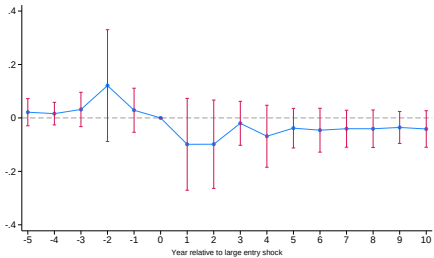
(b) Employment (log)

back

Employment for primary workers in epicenter: Entries in tradable vs. non-tradable sectors



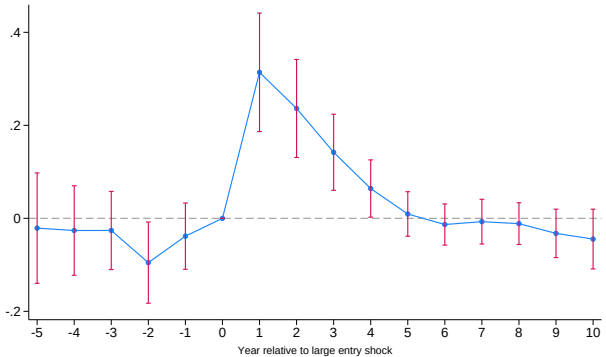
(a) Non-tradable sectors



(b) Tradable sectors

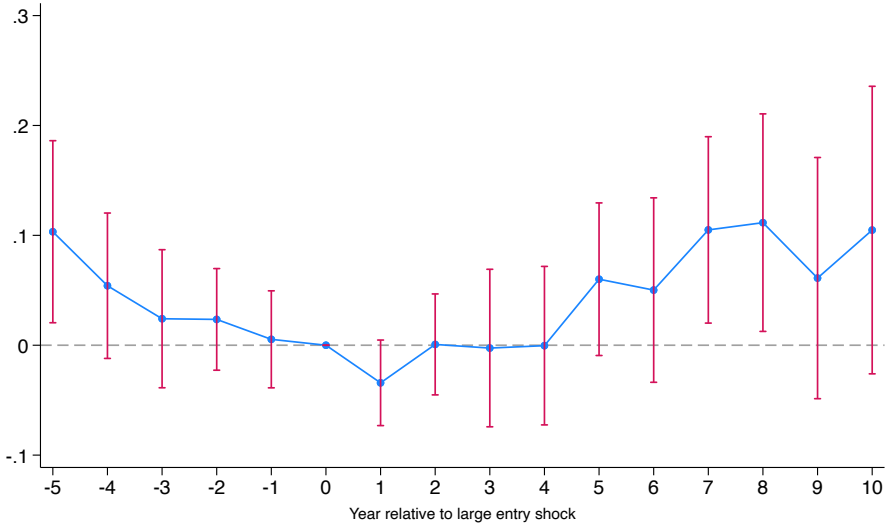
back

Employment for primary workers in epicenter: Entries in construction



back

Area: Large entries increase hectares planted ∼ 5 years later (PAM)



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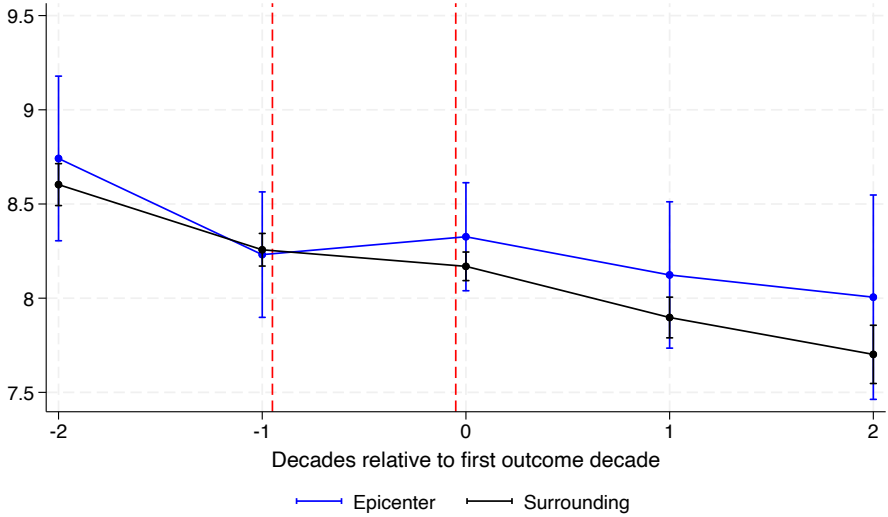
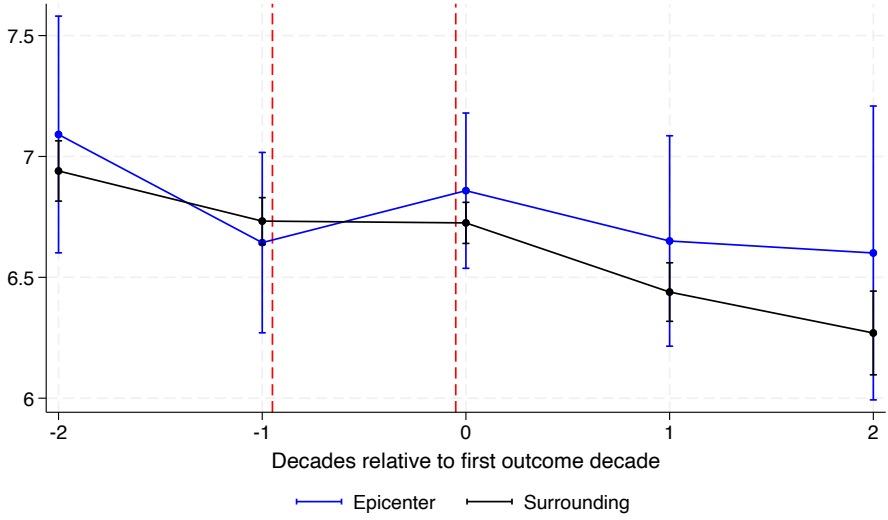
The share of labor in agriculture decreases



back

Share of small farms decreases



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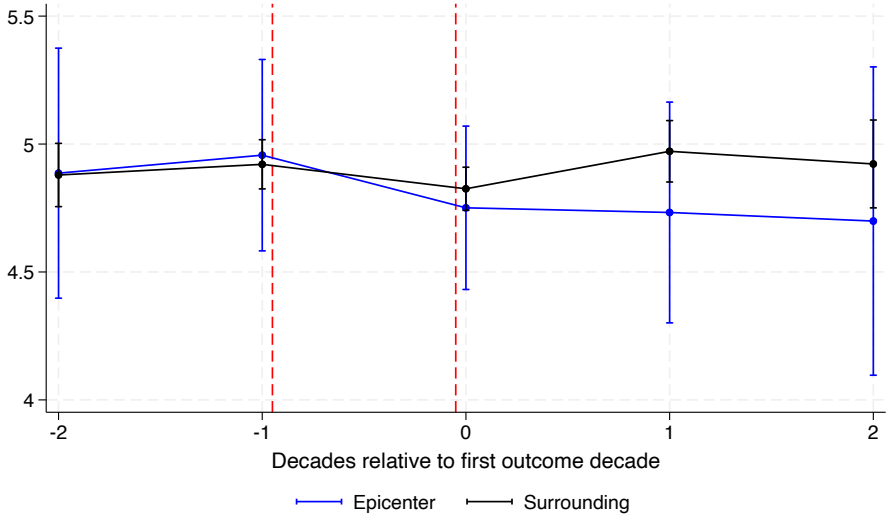
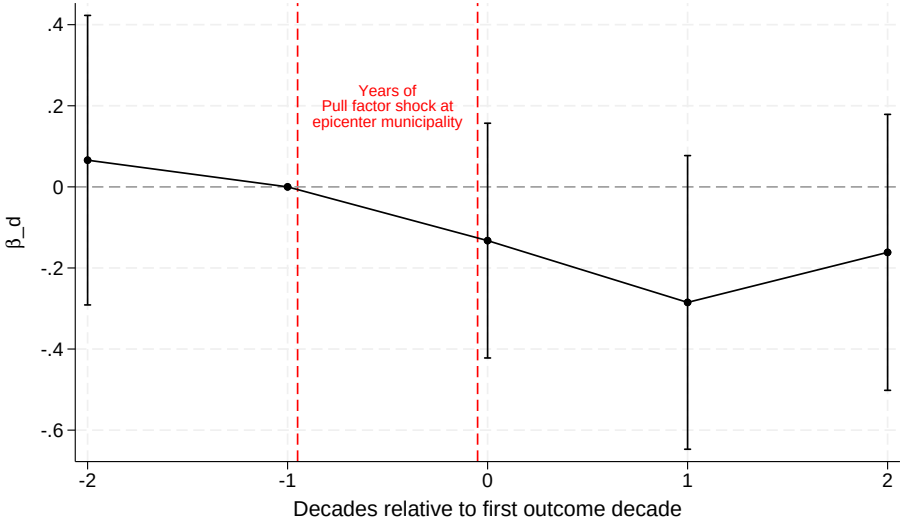
Area per farm increases

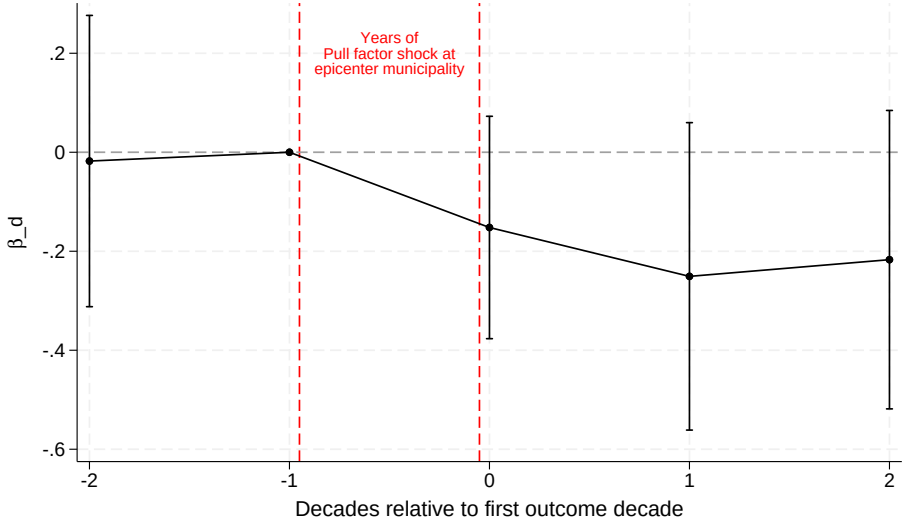


back

A large non-ag entry... Decreases agricultural labor



A large non-ag entry... Decreases the number of small farms



Planner's problem

$$W_t \equiv \max_{\{C_{at}, C_{nt}, C_{at}\}} \sum_t \nu^t \left(\theta_n \ln(C_{nt}) + \theta_a \ln(C_{at} - \bar{c}_a) + \theta_s \ln(C_{st} - \bar{c}_s)\right)$$

$$C_{at} = M_{at} Y_{at}, \qquad (\lambda_a)$$

$$C_{st} = Y_{st}, \qquad C_{nt} + X_t = M_{nt} Y_{nt}. \qquad (\lambda_l)$$

$$K_{t+1} = X_t + (1 - \delta_k) K_t, \qquad (\mu_X)$$

$$M_{it+1} = m_{it}(1 - G(\underline{Z_{it+1}})) + M_{it}(1 - \delta_{M_i}). \qquad (\mu_i)$$

$$M_n \int_{\underline{Z}_n}^{\infty} N_n(Z) g_n(Z) dZ + N_s + M_a \int_{\underline{Z}_a}^{\infty} N_a(Z) g_a(Z) dZ \equiv N^p,$$

$$N^p + N^f = \bar{N}_n + \bar{N}_s. \qquad (\mu_n)$$

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Direct Calibration

Parameter	Description	Value	Source/Moment
α	Share of labor in non-agriculture	0.82	Valentinyi & Herrendorf ('08)
γ_l	Share of land in agriculture	0.18	Valentinyi & Herrendorf ('08)
γ	Share of equipment and labor composite in agriculture	0.71	Valentinyi & Herrendorf ('08)
ι	Comparative advantage in agr.	2	Acemoglu & Zilibotti ('01)
ν	Discount factor	0.96	Annual interest rate of 4%
δ_k	Depreciation rate of equipment in agriculture	0.0294	Caunedo & Keller ('20)
δ_n	Exit rate in non-agriculture	13%	RAIS data, Ulyssea ('18)
δ_a	Exit rate in agriculture	11%	RAIS data
θ_a	Share of agriculture in consumption	0.2	National Accounts
$\theta_s = \theta_n$	Share of non-agriculture in consumption	0.4	National Accounts
f_n	Operating cost non-agriculture	$0.5w$	Ulyssea ('18)
f_a	Operating cost agriculture	$0.1w$	Exogenous, below f_n
F_n	Entry cost in non-agriculture	0.0016	Exogenous
Z_s	Productivity in informal non-agriculture	1	Normalization

normalization $\mathcal{A}(\beta) = 1$

profile of comparative advantage $\frac{a_n(b)}{a_k(b)} \equiv \phi\left(\frac{b}{1-b}\right)^{\iota-1}$ $\rightarrow$ ϕ chosen consistently with $\gamma\beta$ and $\frac{K_a}{Y_a}$

back

Firms in Services/Informality

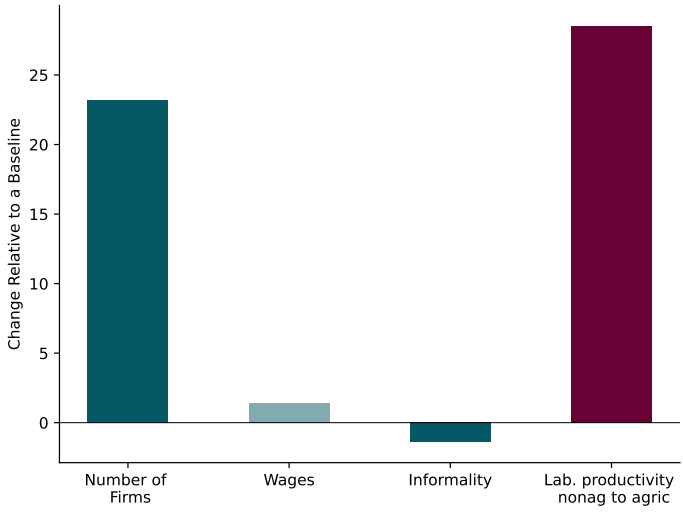
- Production technology

$$Y_s = Z_s N_s^{\alpha}$$

  - Productivity Z_s for the representative firm

back

Firm Entry Shock $\Downarrow F_n$: Non-agriculture ($\bar{c}_a > 0$)



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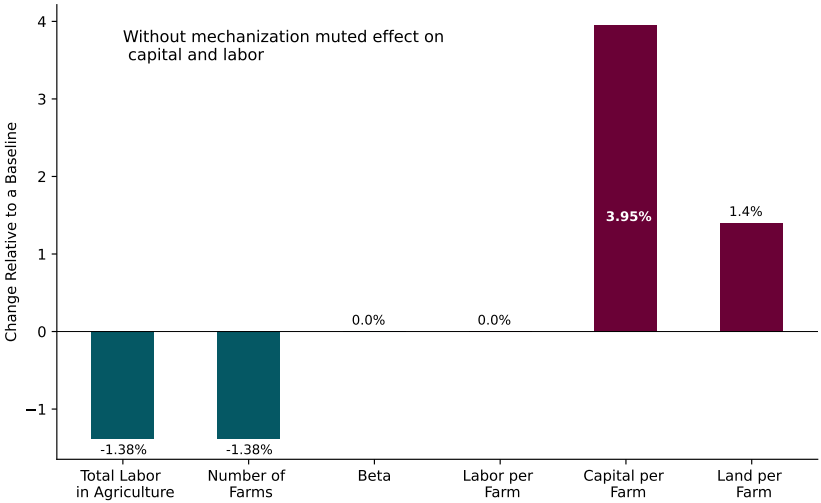
Firm Entry Shock $\Downarrow F_n$: Organization of Agriculture (No Mech.)



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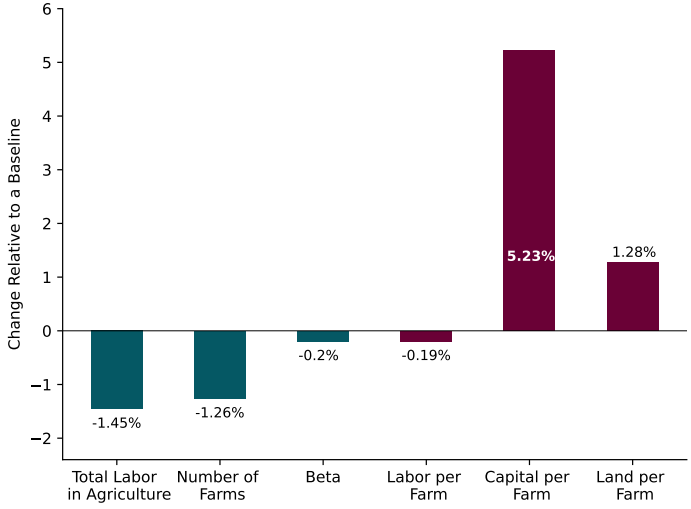
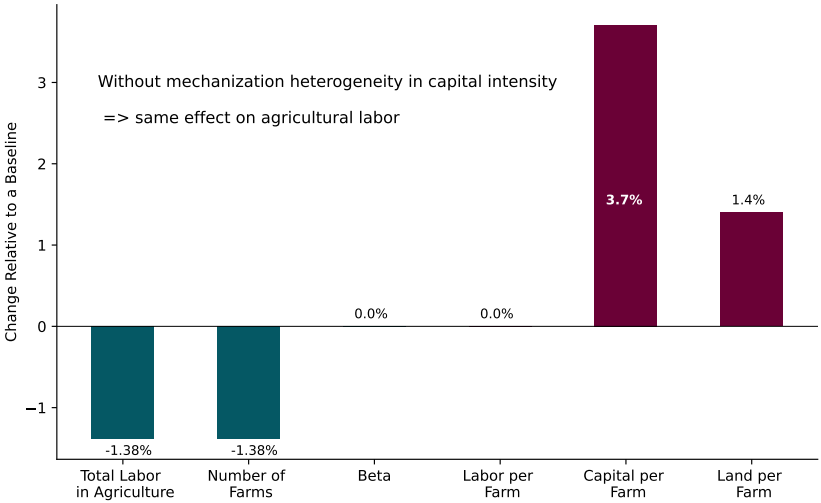
Firm Entry Shock $\Downarrow F_n$: Organization of Agriculture ($\bar{c}_a > 0$)



back

Firm Entry Shock $\Downarrow F_n$: Higher Initial Capital Intensity (No Mech.)



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