Spatial Structural Change

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Spatial Structural Change

Growth $\longmapsto$ Structural Change $\longmapsto$ Decline of Agricultural Sector

Question: Systematic spatial bias?

- Are rural locations hurt by declining demand?
- Does industrialization offer new opportunities for rural labor markets?

This paper: The US experience from 1880-1920

- Empirical finding: growth was rural biased
  - Spatial convergence
- Novel theory of spatial structural change
  - Macro model of structural change + Quantitative spatial model
  - Catch-up growth though technology diffusion
- Quantitative analysis
  - Important role for catch-up growth
  - Main beneficiaries: rural locations

Literature

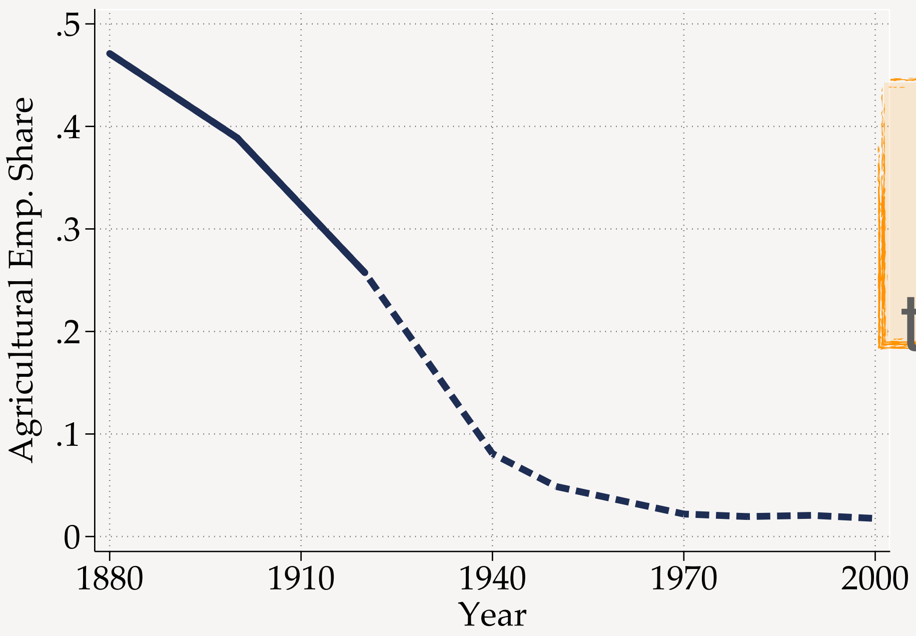
- **Structural Change**
  Herrendorf et al. (2014), Kongsamut et al. (2001), Gollin et al. (2002), Comin et al. (2017), Boppart (2014), Ngai and Pissarides (2007), Acemoglu and Guerrieri (2008), Alvarez-Cuadrado et al. (2017), Caselli and Coleman II (2001), Porzio et al. (2020))

- **Quantitative Geography**
  Allen, Arkolakis (2014), Redding, Rossi-Hansberg (2017), Desmet, Nagy, Rossi-Hansberg (2018), Allen, Donaldson (2022), Peters (2021)

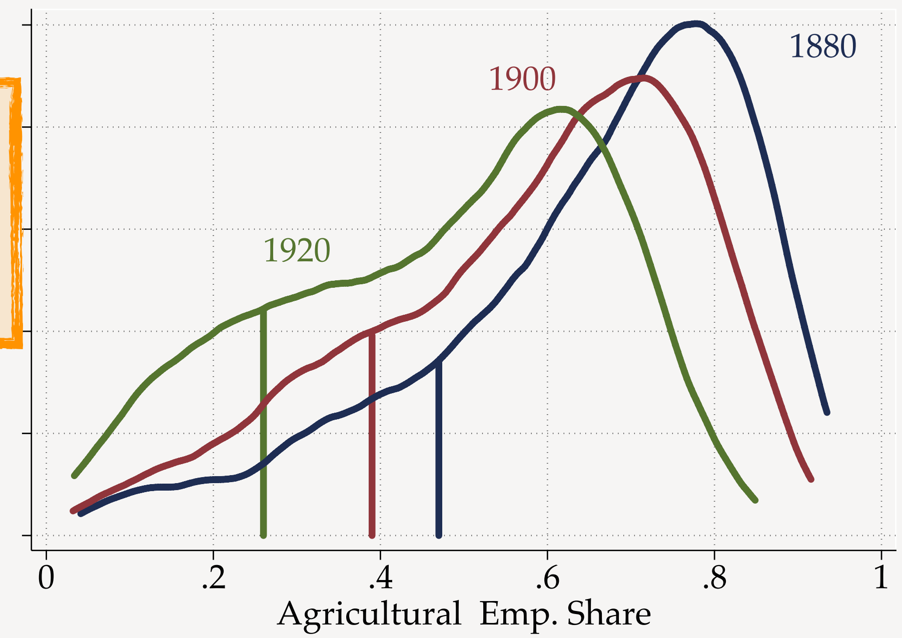
- **Spatial Structural Change**
  Caselli. Coleman (2001), Nagy (2021), Budí-Ors, Pijoan-Mas (2022), Desmet and Rossi-Hansberg (2014), Fan et al. (2021), Eckert et al. (2022)

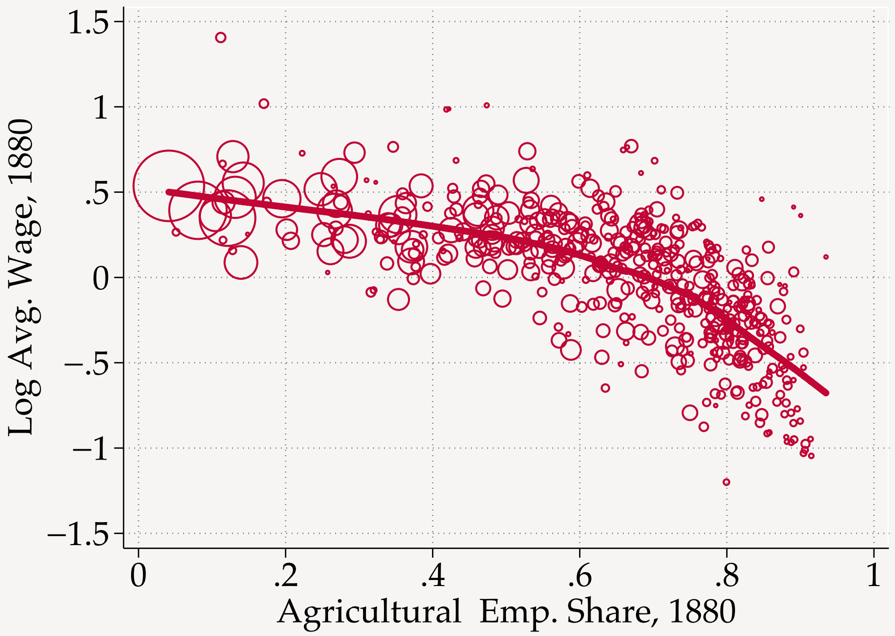
- **Convergence**
  Barro and Sala-i Martin (1992), Acemoglu et al. (2006), Desmet, Rossi-Hansberg (2009)

Spatial Structural Change in the US

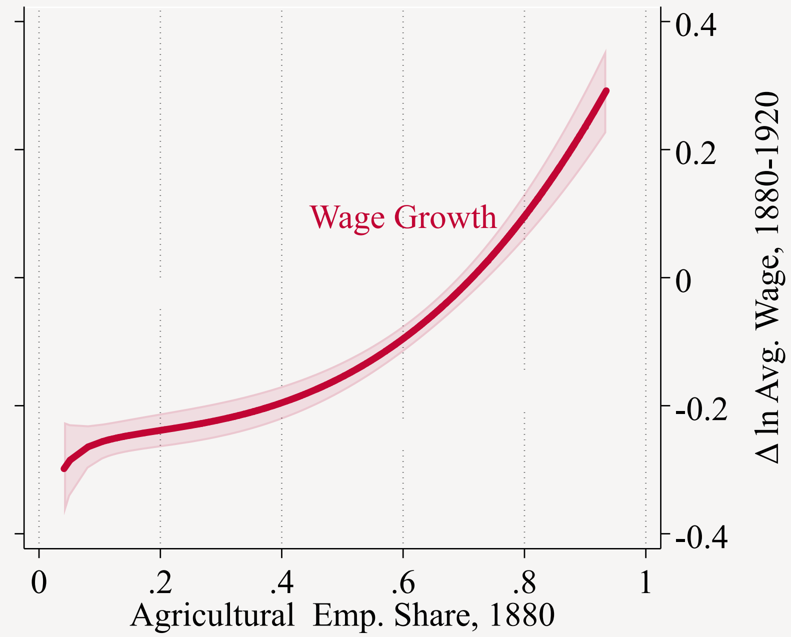


Local structural transformation





Rural catch-up



Today

- Theory
- Mechanism
- Estimation / Calibration
- Quantification: Importance of Rural Catch-Up

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Technology

- R locations, $r = 1, \ldots, R$
- Two sectors $s = A, M$ in each location
  - Agriculture: Homogeneous good

$$Y_{rAt} = Z_{rAt} H_{rAt}^{1-\alpha} T_{rt}^{\alpha}$$

  - Non-agriculture: Differentiated varieties ω

$$y_{rt}(\omega) = Z_{rMt} h_{rMt}(\omega) \qquad \text{and}$$

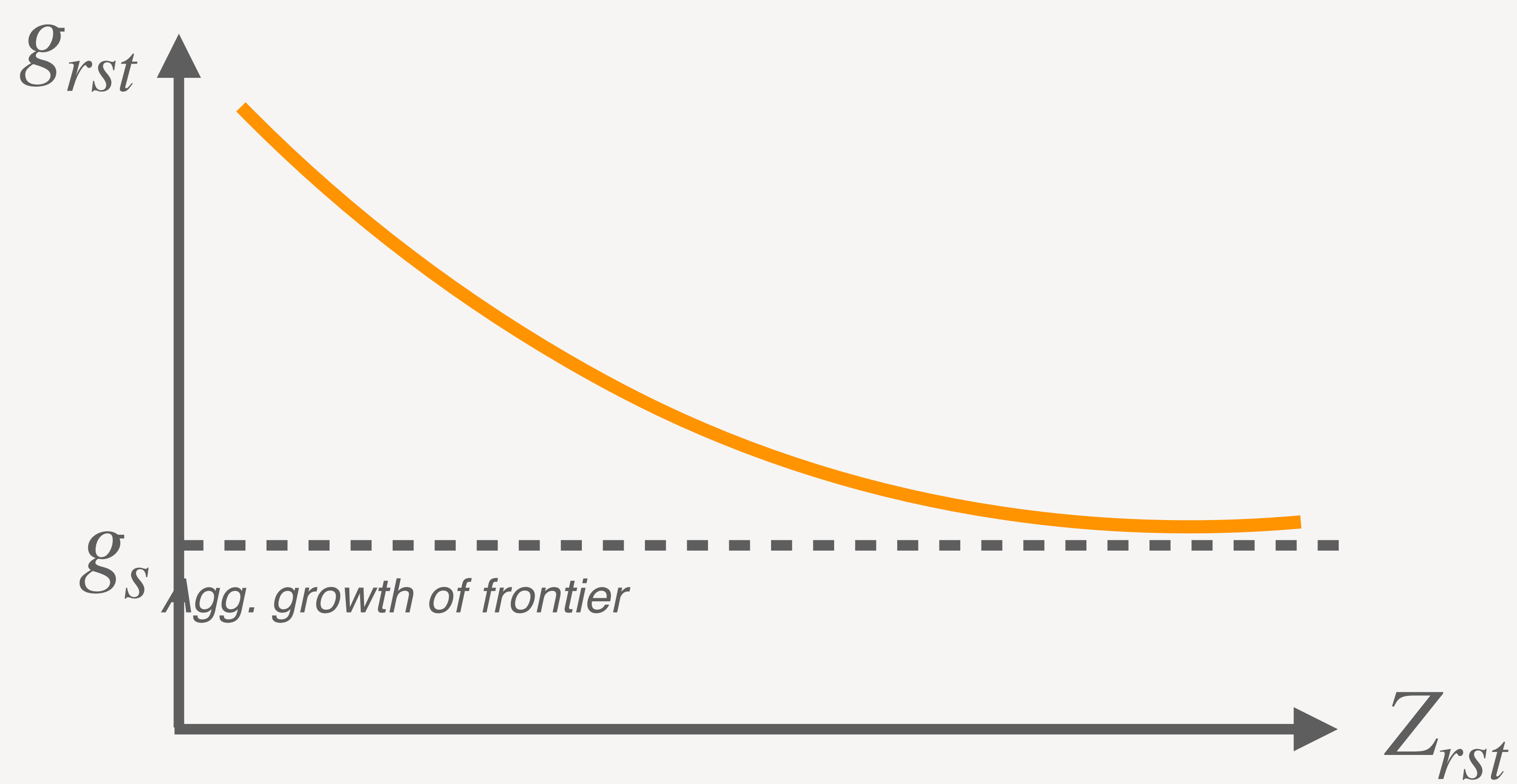
$$Y_{rM} = \left(\sum_{r=1}^{R} \int_{\omega}^{N_{rt}} y_{rt}(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}}$$

Monopolistic competition; free entry at cost $f_E w_{rMt}$

The Spatial Productivity Ladder: Catch-up growth

- In each sector: technological frontier $\bar{Z}_{st}$; constant growth g_s
- Local productivity growth depends on distance to frontier

$$g_{rst} \equiv d \ln Z_{rst} = g_s + \lambda_s \times \ln\left(\bar{Z}_{st}/Z_{rst}\right)$$



Note: Catch-up in rural regions is ***not*** hardwired

Preferences

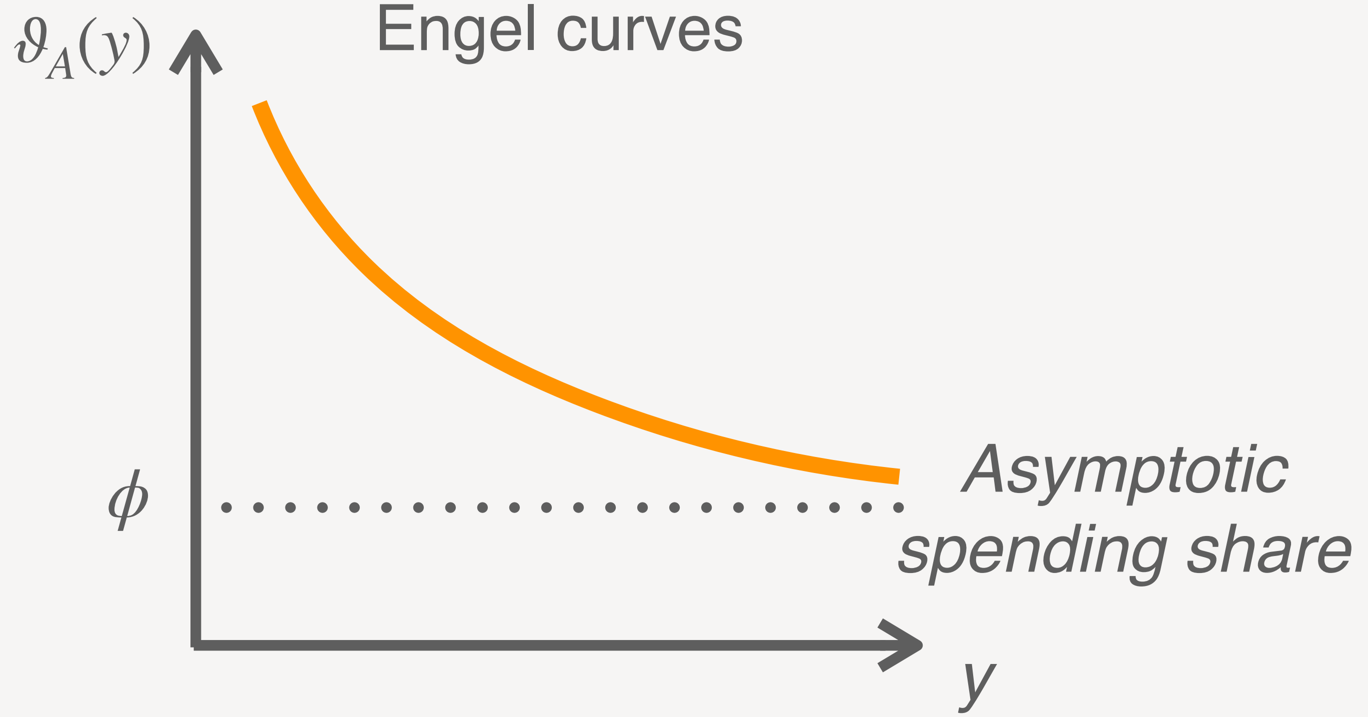
- Nonhomothetic preferences; *PIGL* class [Boppart 2014]

Indirect utility

$$V = \frac{1}{\eta}\left(\frac{y}{P_{rA}^{\phi} P_{rNA}^{1-\phi}}\right)^{\eta} - \nu \ln\left(\frac{P_{rA}}{P_{rNA}}\right) \longmapsto \vartheta_A(y) = \phi + \nu \left(\frac{y}{P_{rA}^{\phi} P_{rNA}^{1-\phi}}\right)^{-\eta}$$

Agricult. expenditure share

Engel curves



- Main appeal of PIGL: Aggregation with heterogeneity

Aggregation EOS

Closing the Model

- Sectoral labor supply:
  - Idiosyncratic Fréchet productivity for each sector
  - ζ = elasticity of substitution of workers across sectors

$$H_{rs} = \Gamma_\zeta L_r \left(w_{rs}/\bar{w}_r\right)^{\zeta-1}$$

- Spatial labor supply:
  - Moving costs μ_{jr} and Fréchet taste draw with shape ε; amenities $\mathscr{B}_{rt} = B_r L_{rt}^{-\rho}$
  - Exog. population shocks n_{rt}: intl. migration & fertility
  - Slow-moving population dynamics

$$\mathscr{V}_{rt} = \int V_{rt}(y)dF_{rt}(y$$

$$L_{rt} = \sum_j m_{jrt} n_{jt-1} L_{jt-1} \quad \text{where} \quad m_{krt} = \frac{\left(\mu_{kr}\mathscr{V}_{rt}\mathscr{B}_{rt}\right)^{\varepsilon}}{\sum_j \left(\mu_{rj}\mathscr{V}_{jt}\mathscr{B}_{jt}\right)^{\varepsilon}}$$

Static equilibrium: Characterization

- Two useful endogenous objects:
  - Manufacturing market access: $\mathcal{D}_{rt} \equiv \sum \tau_{rj}^{1-\sigma} P_{jMt}^{\sigma-1} \left(1 - \vartheta_{jAt}\right) \Gamma_{\zeta} L_{jt} \overline{w}_{j}$
  - Agricultural population density: $\ell_{rt} \equiv L_{rt}/T_{rt}$

Proposition: Let $\mathcal{Z}_{rMt} \equiv \mathcal{D}_{rt}^{\frac{1}{\sigma}} Z_{rMt}^{\frac{\sigma-1}{\sigma}}$ *and* $\mathcal{Z}_{rAt} \equiv Z_{rAt} \ell_{rt}^{-\alpha}$. *Then*

$$w_{rMt} = \mathcal{Z}_{rMt} \quad ; \quad \left(\left(\frac{\mathcal{Z}_{rMt}}{w_{rAt}}\right)^{\zeta} + 1\right)^{\frac{\zeta-1}{\zeta}} \left(\frac{\mathcal{Z}_{rAt}}{w_{rAt}}\right)^{\frac{1}{\alpha}} = 1 \quad ; \quad \frac{s_{rA}^{1+(\zeta-1)\alpha}}{1 - s_{rA}} = \left(\frac{\mathcal{Z}_{rAt}}{\mathcal{Z}_{rMt}}\right)^{\zeta}$$

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Drivers of Spatial Structural Change

- Determinants of local wage growth $d \ln \overline{w}_{rt}$ and local industrialization ds_{rAt}

$\gamma \equiv \alpha(\zeta - 1)$

Local income growth:

$$d \ln \overline{w}_{rt} = \underbrace{\phi\left(s_{rA}\right)}_{\text{Exposure ("Bartik")}} \underbrace{d \ln \mathcal{Z}_{rMt}}_{\text{Shock}} + \underbrace{\left(1 - \phi\left(s_{rA}\right)\right)}_{\text{Exposure ("Bartik")}} \underbrace{d \ln \mathcal{Z}_{rAt}}_{\text{Shock}}$$

$$\phi_{NA}(s_{rA}) = \frac{(\gamma + 1)\left(1 - s_{rA}\right)}{\gamma\left(1 - s_{rA}\right) + 1}$$

s_{rA} = sufficient statistic

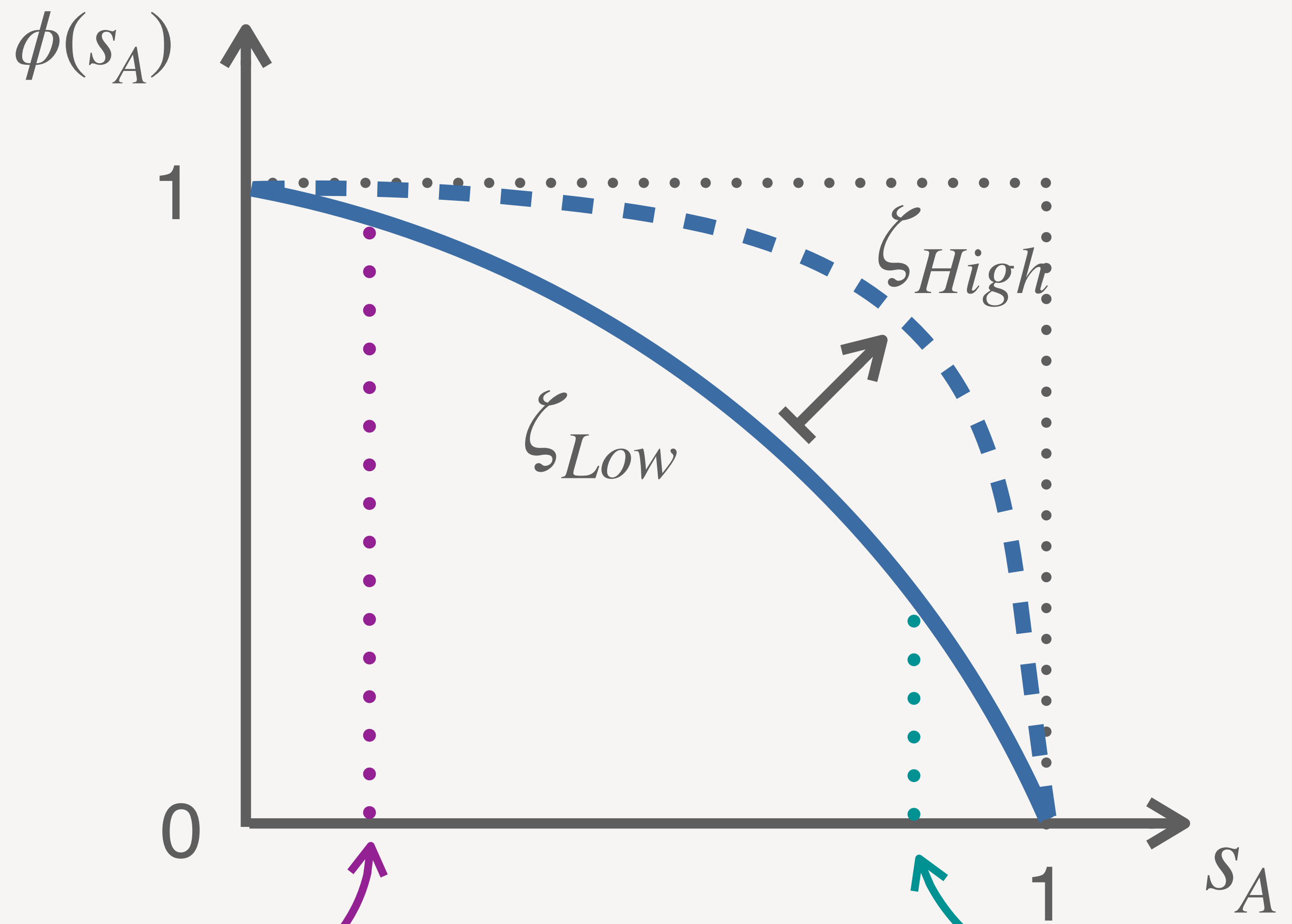
Local industrialization:

$$ds_{rAt} = \underbrace{\psi\left(s_{rA}\right)}_{\text{Exposure ("Bartik")}} \left(\underbrace{d \ln \mathcal{Z}_{rMt}}_{\text{Shock}} - \underbrace{d \ln \mathcal{Z}_{rAt}}_{\text{Shock}}\right)$$

$$\psi\left(s_{rA}\right) = -\frac{s_{rA}\left(1 - s_{rA}\right)\zeta}{\gamma\left(1 - s_{rA}\right) + 1}$$

Spatially Biased Exposure: Wage Growth

$$d \ln \overline{w}_{rt} = \phi\left(s_{rA}\right) d \ln \mathscr{Z}_{rMt} + \left(1 - \phi\left(s_{rA}\right)\right) d \ln \mathscr{Z}_{rAt}$$



Higher sectoral elasticity ζ

$\longmapsto$

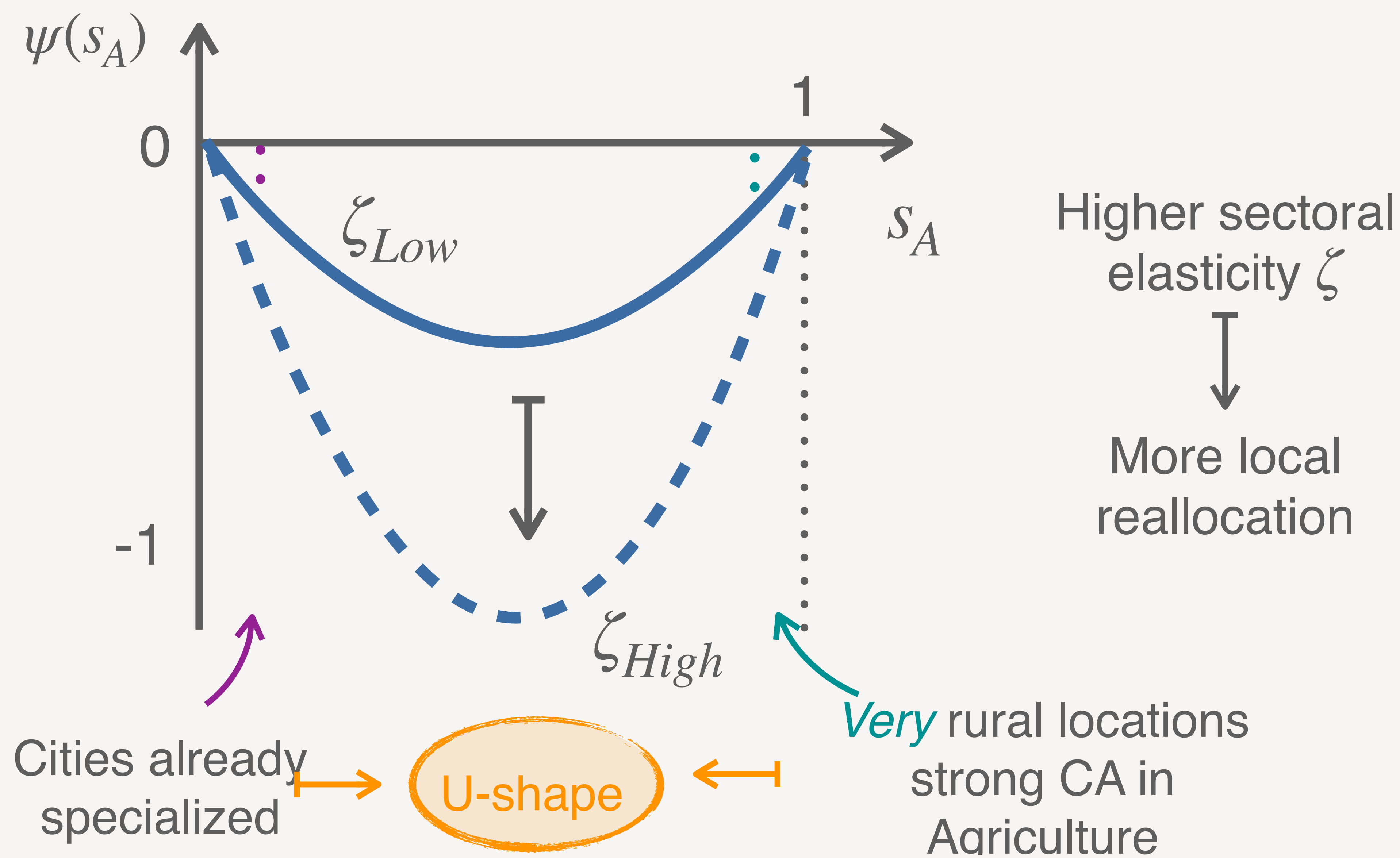
Rural regions participate in $\mathscr{Z}_{rMt}$

Cities benefit from $\mathscr{Z}_{rMt}$

Rural locations benefit from $\mathscr{Z}_{rAt}$

Spatially Biased Exposure: Industrialization

$$ds_{rAt} = \psi\left(s_{rA}\right)\left(d\ln \mathcal{Z}_{rMt} - d\ln \mathcal{Z}_{rAt}\right)$$



Can heterogeneity in exposure be enough?

- Suppose effective productivity growth was common [$\lambda_s = 0, \tau = 1$, No mobility]

$$d \ln \mathscr{Z}_{rst} \equiv \iota_s$$

- Local growth:

$$d \ln \overline{w}_{rt} = d \ln \iota_A + \phi\left(s_{rA}\right)\left(d \ln \iota_M - d \ln \iota_A\right)$$

>0

$$ds_{rAt} = \psi\left(s_{rA}\right)\left(d \ln \iota_M - d \ln \iota_A\right)$$

<0 >0

$\phi'(s_A) < 0 \longrightarrow$ Urban bias!

Declining agricultural employment

Rural bias $\longrightarrow \mathscr{Z}_{rst}$ must have grown faster in rural America!

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- Theory
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Data

- Panel of 503 commuting zones for 1880, 1900, 1920
  - Agricultural Employment Shares *(Decennial Census)*
  - Total Employment *(Decennial Census)*
  - Average Earnings in Manufacturing *(Census of Manufacturing)*
  - Average Value of Acre of Farm Land *(Census of Agriculture)*
- "Historical Statistics of the United States"
  - Time Series Data on GDP per capita, relative sectoral prices

Estimation Strategy

- Model inversion / Accounting: $\{Z_{rM1880}, Z_{rA1880}, T_{r1880}, B_{r1880}\}_r$
- Time-Series estimation ("Macro"): $\{\eta, \nu, \phi\}$, $\{g_M, g_A\}$
- Indirect inference: $\{\lambda_M, \lambda_A, \zeta\}$

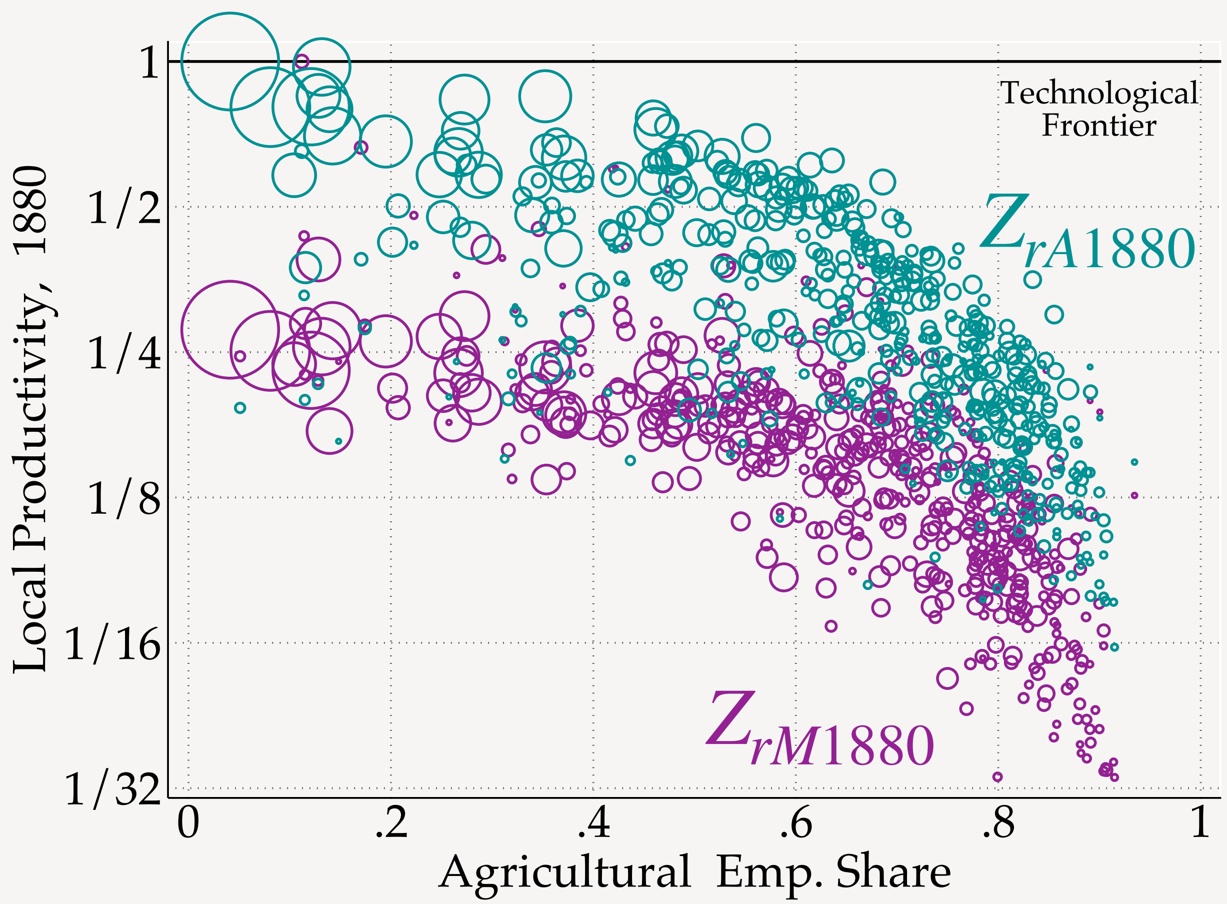
$$d \ln \bar{w}_{rt} = \delta_t + \beta_w s_{rAt} + \nu_{rt} \qquad ds_{rAt} = \delta_t + \beta_{s_A} s_{rAt} + \gamma_{s_A} s_{rAt}^2 + u_{rt}$$

- Other targets: $\{\mu, \tau, \varepsilon\}$
- Exogenous: $\{\alpha, \sigma\}$

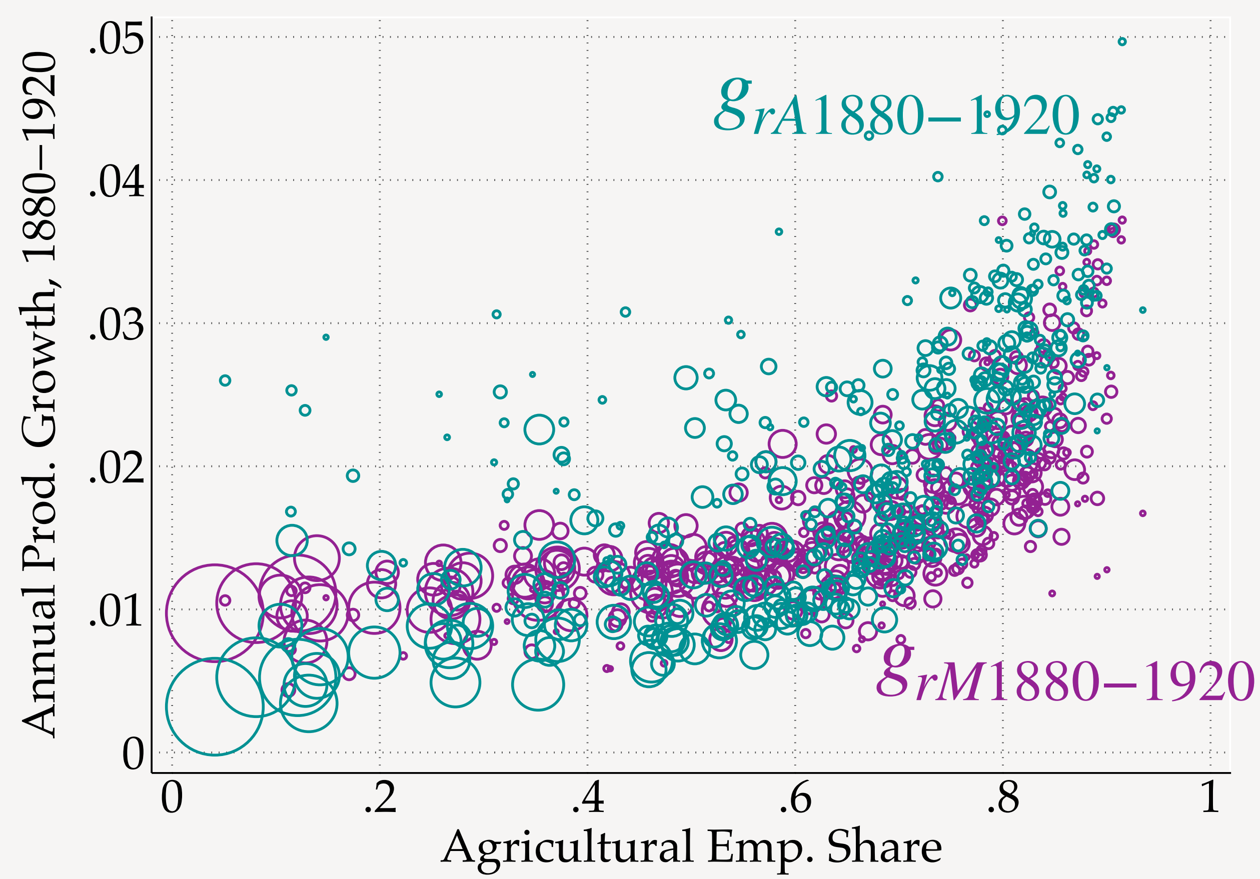
Parameters Moments

Rural Catch-Up: Estimates

The Productivity Ladder in 1880



The Rural Growth Premium

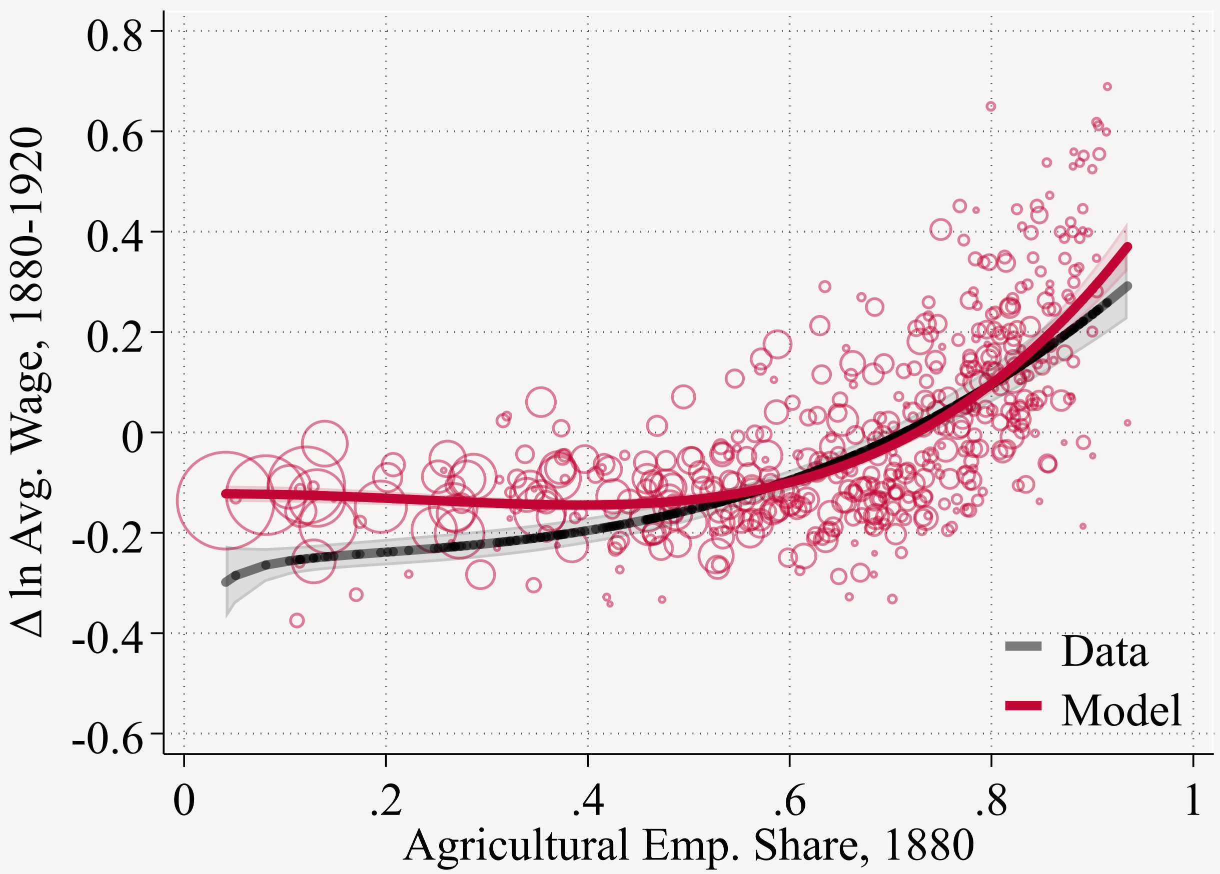


- Paper: Direct evidence for rural catch-up
  - Educational attainment, Financial developments, Capital deepening

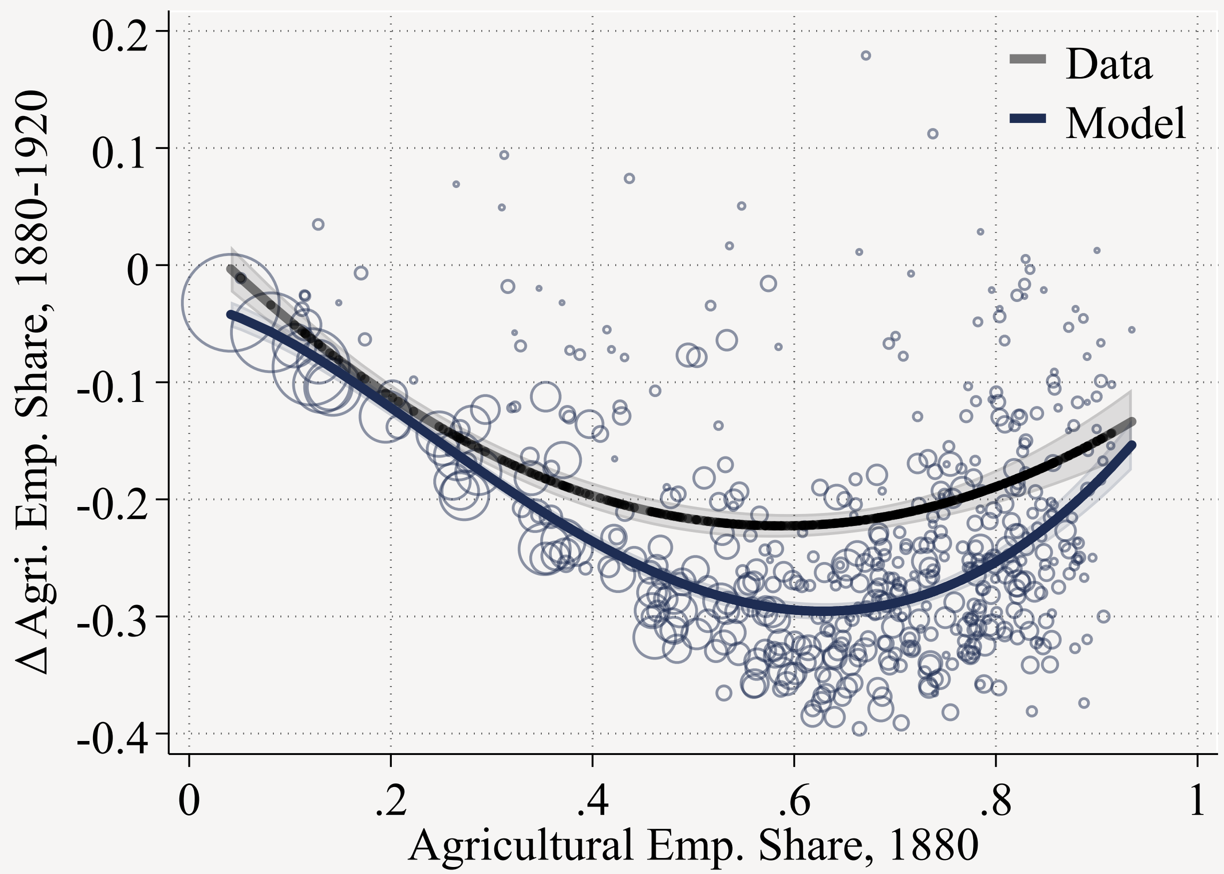
Details

Model Fit

Rural Wage Growth



Rural Industrialization



Population Growth

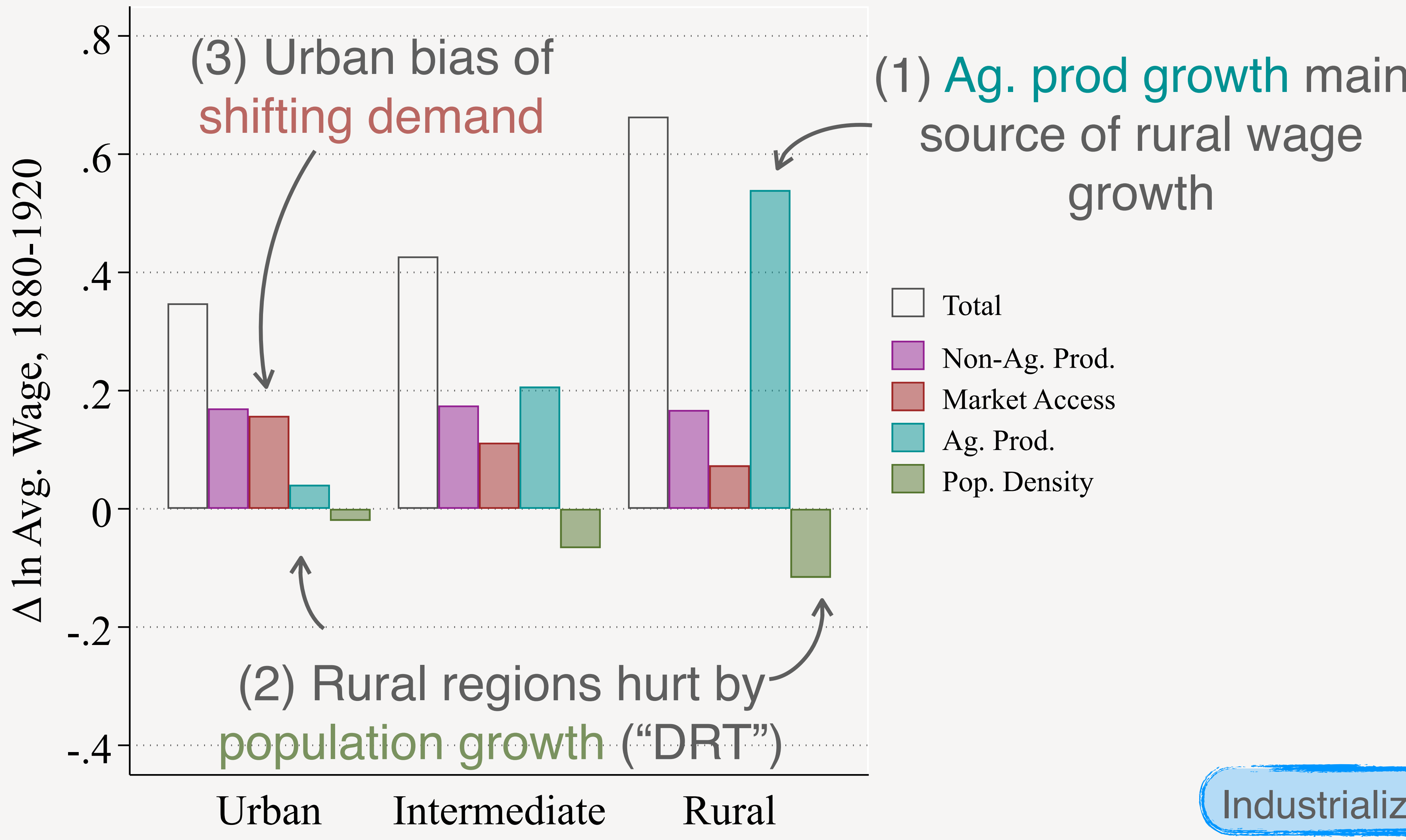
Today

- Theory
- Mechanism
- Estimation / Calibration
- Quantification: Importance of Rural Catch-Up

The Sources of Rural-Biased Growth

$$d \ln \overline{w}_{rt} = \phi\left(s_{rA}\right) \times \left(\frac{\sigma-1}{\sigma} d \ln Z_{rMt} + \frac{1}{\sigma} d \ln \mathscr{D}_{rt}\right) + \left(1-\phi\left(s_{rA}\right)\right) \times \left(d \ln Z_{rAt} - \alpha d \ln \ell_{rt}\right)$$

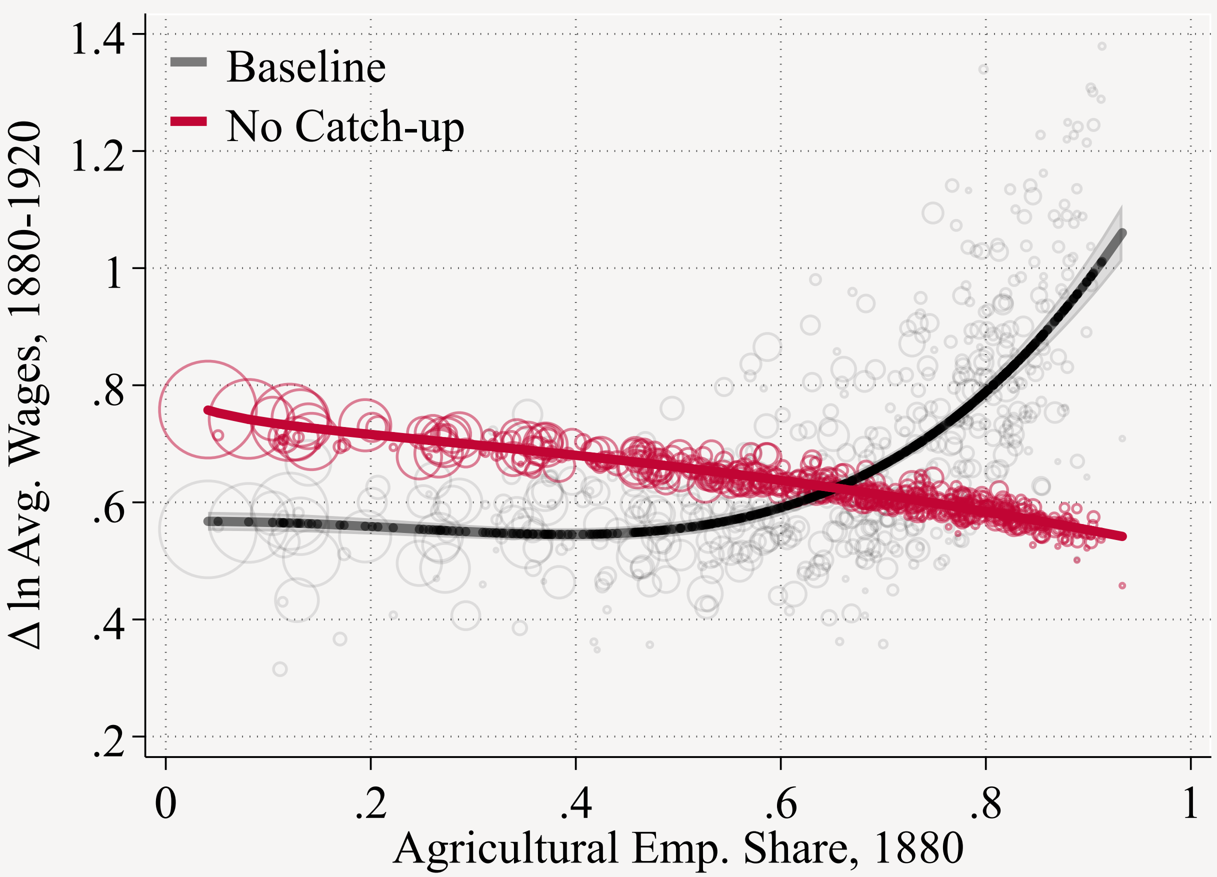
Non-Ag. Prod. | Demand | Ag. Prod. | Pop. density

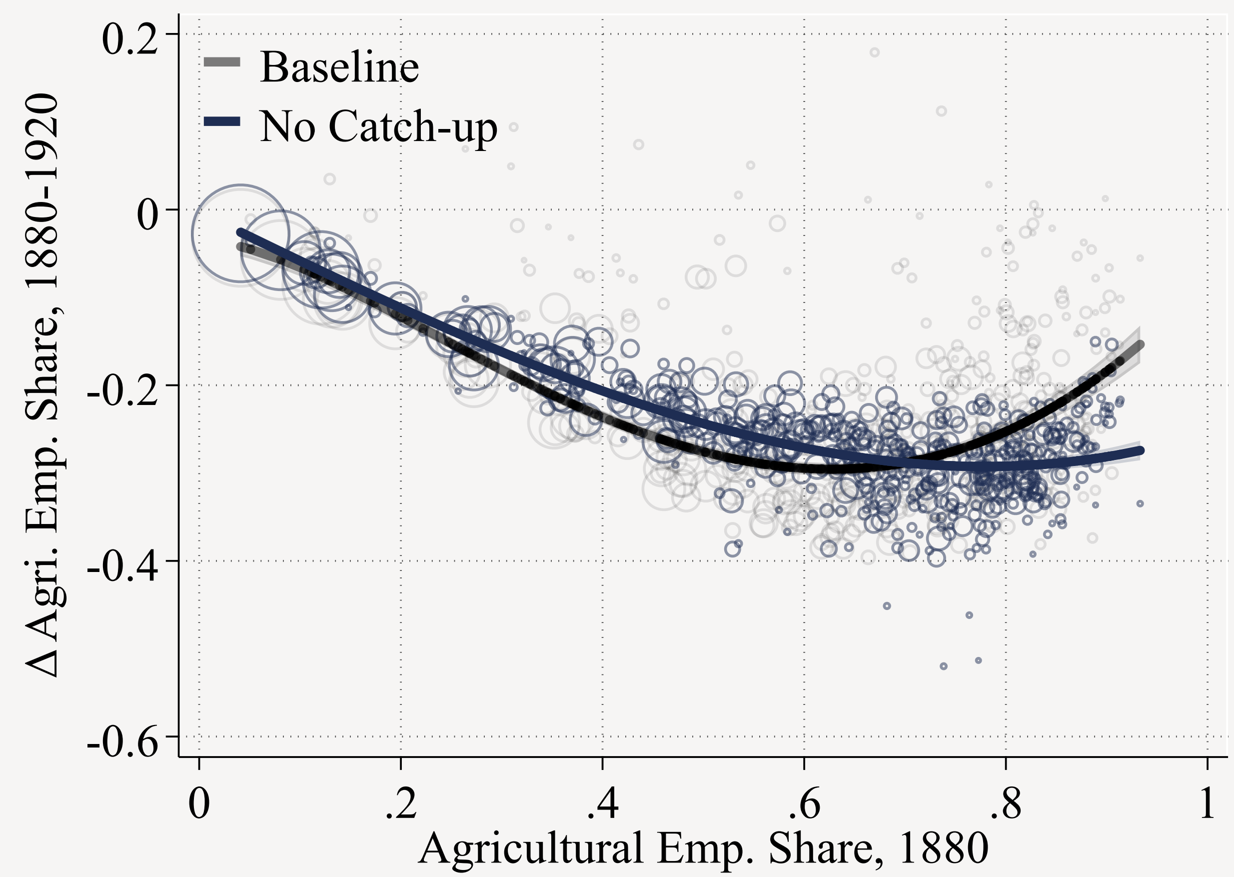


Industrialization

The Importance of Rural Catch-up

- Counterfactual “No-catch macro” calibration
  - Set $\lambda_M = \lambda_A = 0$
  - Recalibrate frontier growth g_M and g_A to match time-series moments





Urban biased growth

No U-shape

Convergence

Conclusion

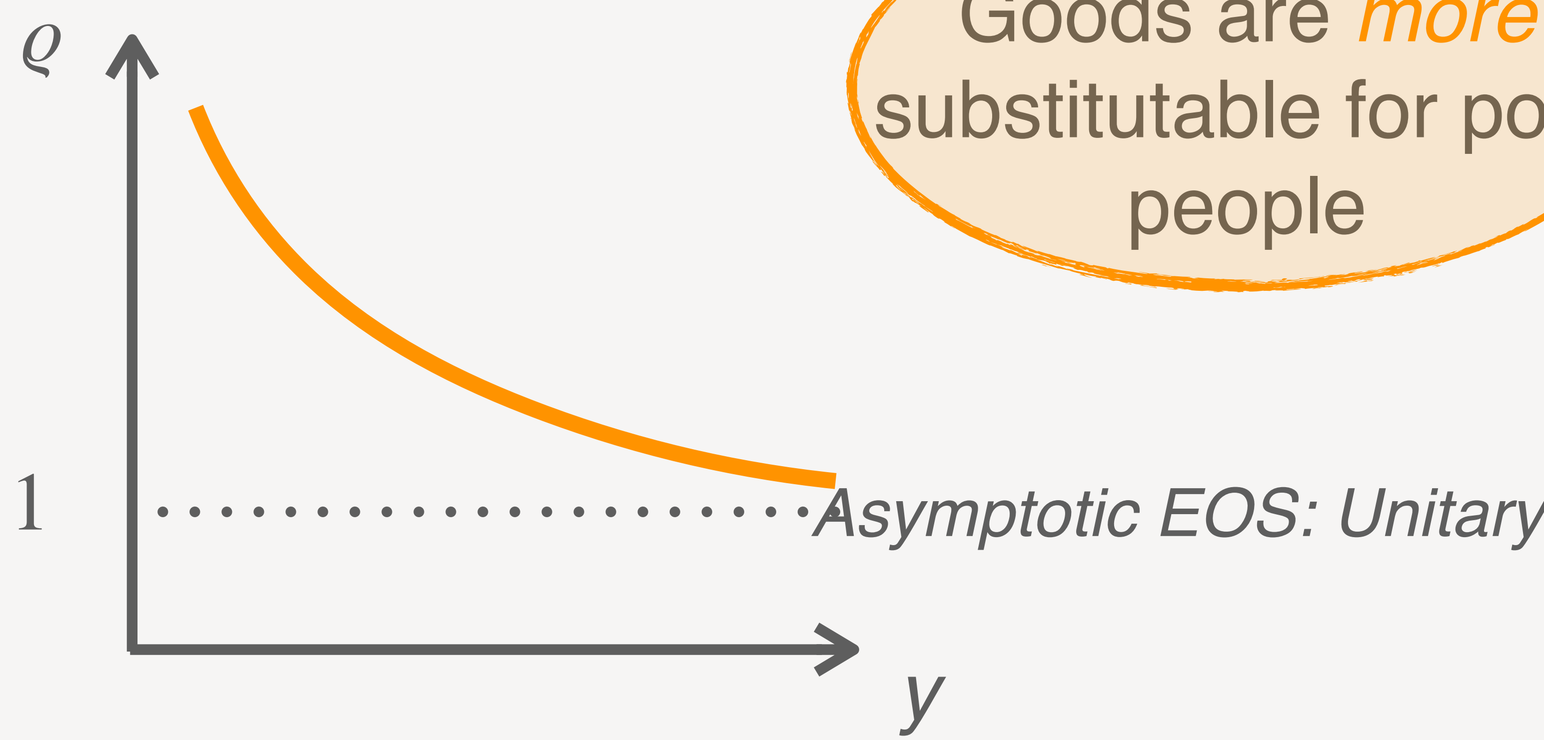
- US growth 1880-1920: Rural-biased
  - Faster wage growth & industrialization in rural areas
  - Spatial convergence
- Mechanism: Catch-up growth
  - Rural locations: at the bottom of the ladder in 1880
  - Catch-up growth = new opportunities to industrialize
- Looking ahead: Transition to services
  - Spatial divergence, not convergence
  - Service productivity = human capital; rival across space?

Appendix

Elasticity of Substitution

- The elasticity of substitution is given by

$$\varrho = 1 + \eta \frac{\left(\vartheta_A - \phi\right)^2}{\vartheta_A \left(1 - \vartheta_A\right)}$$



Goods are *more* substitutable for poor people

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Aggregation: PIGL meets Frechet

With PIGL: analytical expression for aggregate demand and indirect utility

- *Aggregate Demand:*
$$\vartheta_{rA} \equiv \frac{\int \vartheta_A \left(y, p_r\right) y dF_r\left(y\right)}{\int y dF_r\left(y\right)} = \phi + \nu^{\text{RC}} \left(\overline{w}_r / P_{rM}^{1-\phi}\right)^{-\eta}$$
where
$$\nu^{\text{RC}} \equiv \nu \frac{\Gamma_{\zeta/(1-\eta)}}{\Gamma_\zeta}$$

- *Indirect utility:*
$$\mathscr{V}_r = \int V\left(y, p_r\right) dF_r\left(y\right) = \frac{1}{\eta} \Gamma_{\frac{\zeta}{\eta}} \left(\overline{w}_r / P_{rM}^{1-\phi}\right)^{\eta} - \nu \ln\left(1/P_{rM}\right)$$

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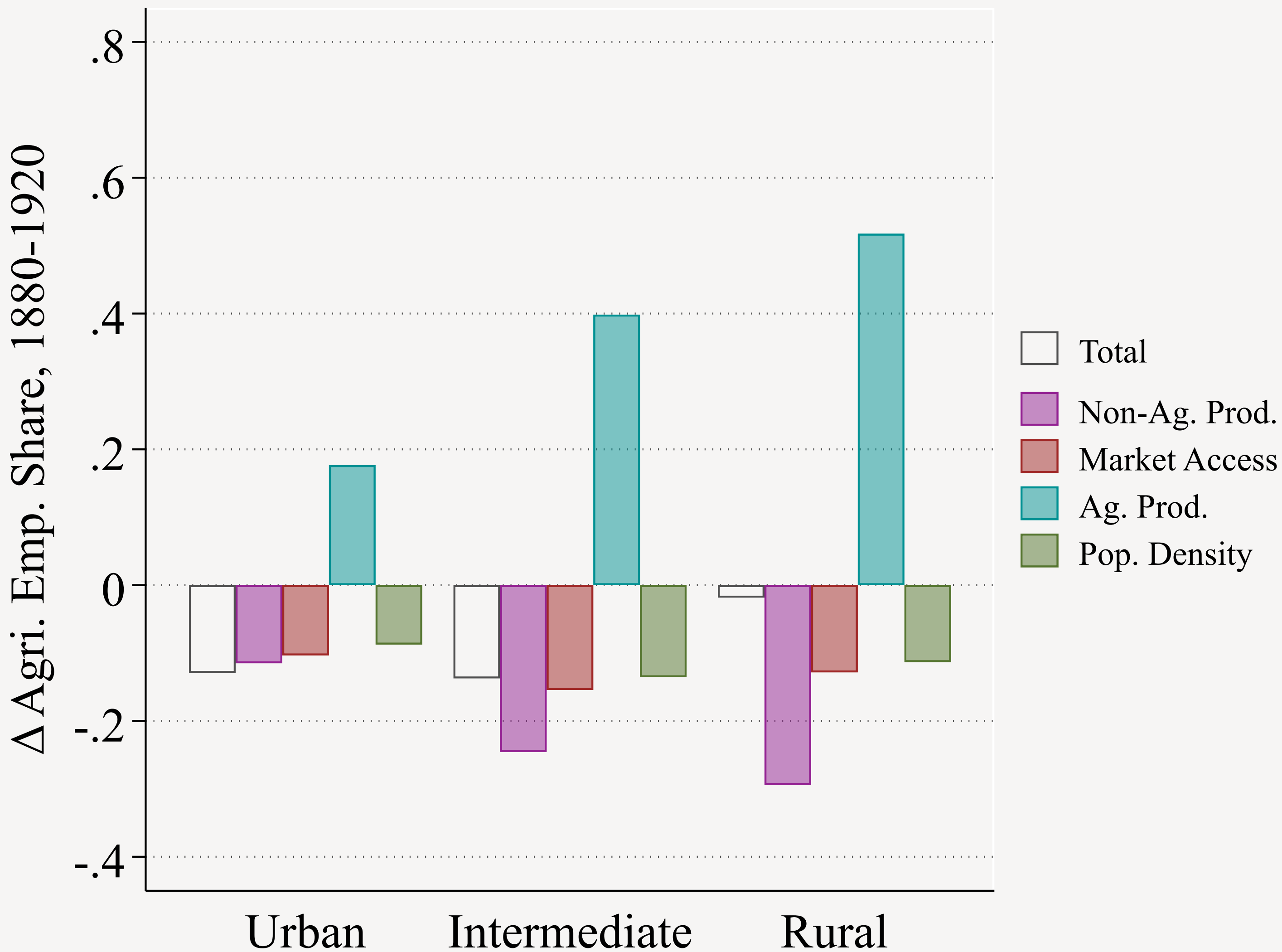
The Sources of Rural Industrialization

$$ds_{rAt} = \psi\left(s_{rA}\right) \times \left(\frac{\sigma-1}{\sigma} d\ln Z_{rMt} + \frac{1}{\sigma} d\ln \mathscr{D}_{rt} - \left(d\ln Z_{rAt} - \alpha d\ln \ell_{rt}\right)\right)$$

Non-Ag. Prod. | Demand | Ag. Prod. | Pop. density



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Rural Catch-up: Empirical Evidence

TABLE 2: DRIVERS OF RURAL CATCH-UP

	GROWTH IN...					
	GENERAL		SECTOR-SPECIFIC FACTORS			
	Banks pc	School Attendance	Agri. Machinery	Farm Size	Non-agri. Machinery	Plant Size
Agri. Emp. Share	0.117***	0.007***	0.032***	0.012***	0.039***	0.032***
	(0.006)	(0.001)	(0.002)	(0.003)	(0.009)	(0.007)
R^2	0.723	0.331	0.359	0.107	0.090	0.242
N	495	495	495	495	495	495

Notes: The dependent variables are the growth rate in the number of banks per capita from Jaremski and Fishback [2018] (Column 1), the change in the share of children attending school from the Decennial Census (Column 2), and the growth rates of the sectoral capital stocks and average employment per farm/firm from the Census of Manufacturing (Columns 5 and 6) and the Census of Agriculture (Columns 3 and 4). All regressions are employment weighted.

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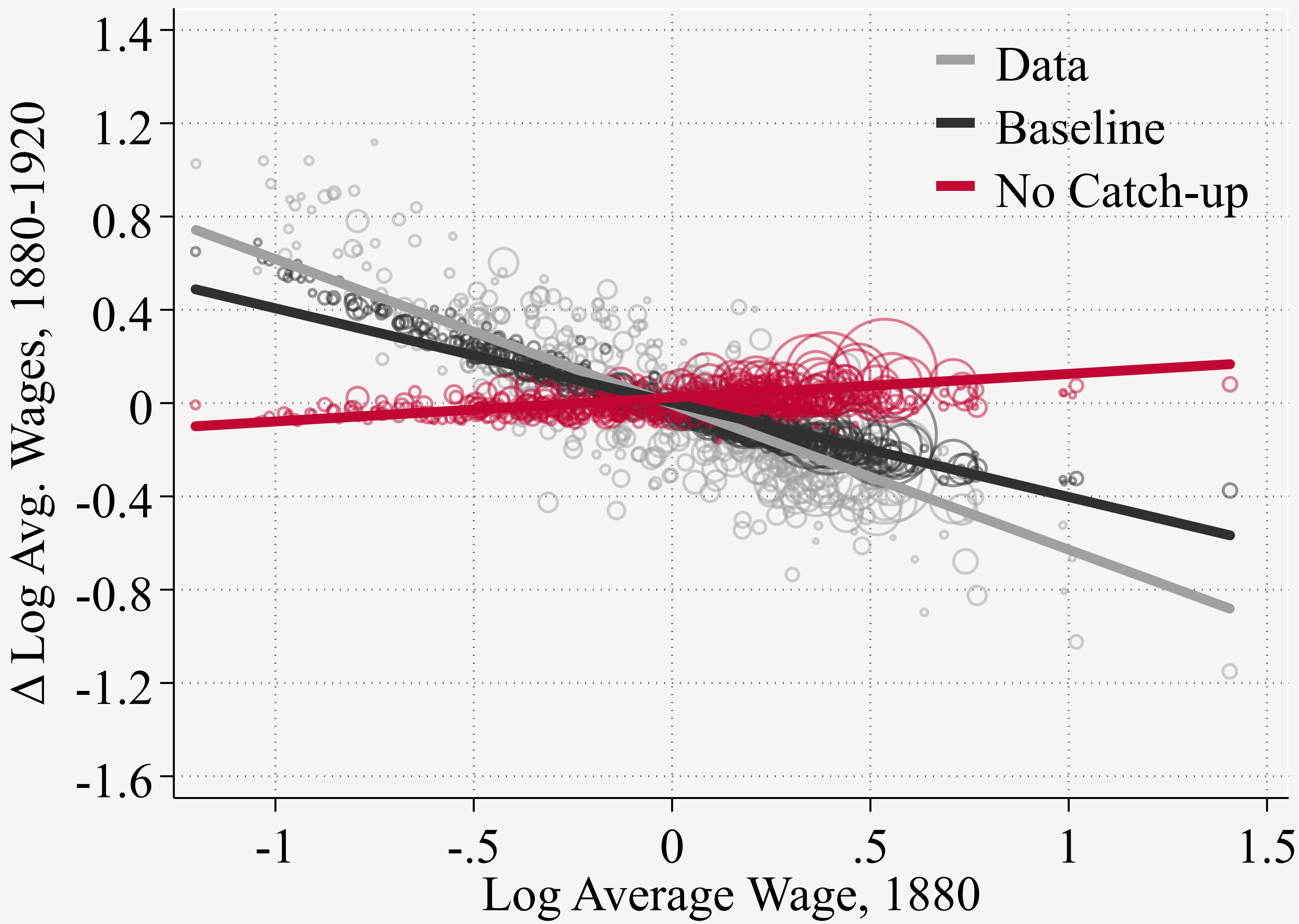
Catch-up and Convergence



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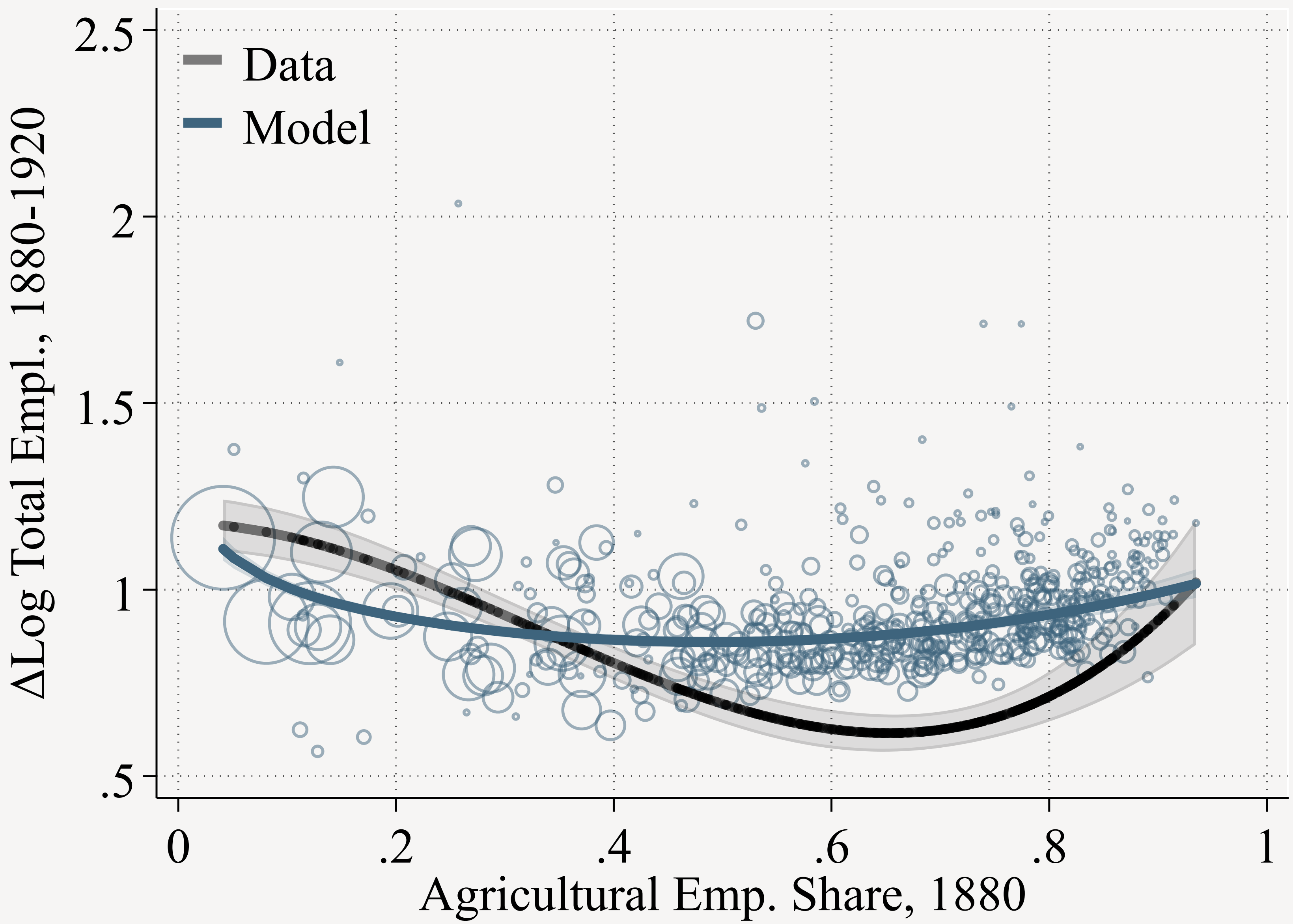
Model Fit: Population Growth



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Estimated Parameters & Moments

Structural Parameters			Estimation Method		
	Description	Value	Panel A: In-Model (Moment, Data, Model)		
ζ	Labor Supply Elasticity	6.9	γ_{sA} in regression (17)	0.45	0.51
			$E[s_{rA1920} - s_{rA1880} \| s_{rA1880} > 0.8]$	-0.20	-0.20
λ_A	Catch-Up in Agricult.	0.21	β_w in regression (17)	0.25 0.16	
g_A	Growth of Agricult. Frontier	0.07	Ag. Empl. Share 1900	0.39	0.35
		0.12	Ag. Empl. Share 1920	0.26	0.25
λ_M	Catch-Up in Non-agricult.	0.05	β_{sA} in regression (17)	-0.48	-0.57
g_M	Growth of Non-agricult. Frontier	0.09	GDP growth 1880-1900	1.43	1.50
			GDP growth 1900-1920	2.04	2.05
ϵ	Location Taste Heterogeneity	3.80	Avg. Migration Elasticity	2	2.03
			β_l in regression (19)	-0.36	-0.04
η	Engel Elasticity	0.93	Rel. price P_M/P_A 1900	0.94	1.01
ν	PIGL preference parameter	0.12	Rel. price P_M/P_A 1920	0.89	0.87
			Panel B: Out-of-Model (Strategy)		
κ	Migration Cost Distance Elasticity	2.8	Gravity relationship of migration flows		
θ	Trade Costs Distance Elasticity	1.35	Gravity relationship of trade flows		
			Panel C: Exogenously-Set (Source)		
σ	Elastictiy of Substitution Mfg Good	6	NA		
ρ	Amenity Congestion Elasticity	0.15	Allen and Donaldson [2020]		
α	Land Share in Production Function	0.4	Valentinyi and Herrendorf [2008]		
ϕ	Asy. Exp. Share on Agricult. Goods	0.01	NA		

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