The Malthusian Income Gap: Theory and Evidence from Colonial South Asia

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Motivation: get me out of this (Malthusian) trap

- Orthodox view of the preindustrial economy: stuck at the Malthusian steady-state (income only determined by demographic behavior)
- Economic historians in this room: the past is about growth and shrinkage, convergence and divergence, income dispersion
  - ▷ Implies that demographic behavior is not always Malthusian
- If excess population density was the problem, why would migrating to the many sparsely populated lands of a sparsely populated world not be a way to escape the trap?
  - ▷ 15M left England in the 19th Century. Pomeranz' 'ghost acres' and emigration as pressure relief, key to the industrial revolution?

Context: colonial South Asia, 1870-1930

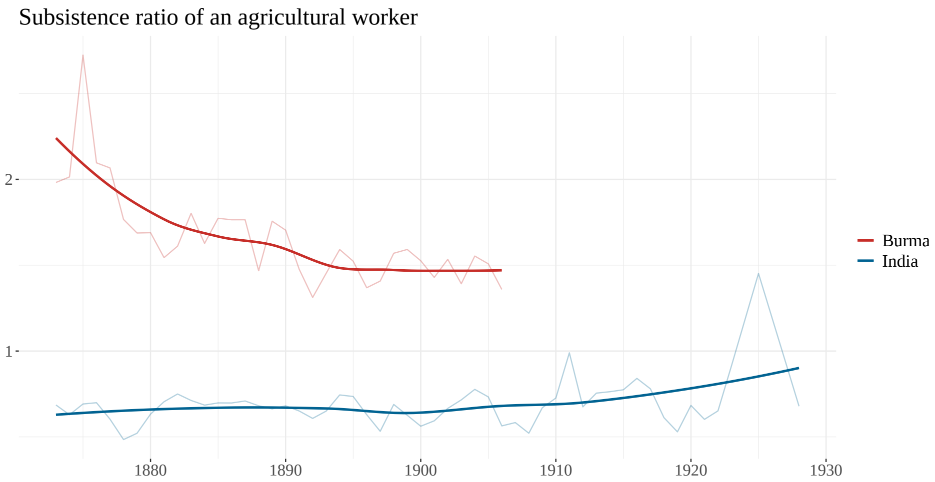
- British India = Modern India, Pakistan, Bangladesh and Myanmar. Large (ca. 500M inhab.) and heterogeneous (real wage gap $>$ 100 pc.) agricultural economy.
- British direct rule: centralized authority collecting local statistics over 70 years (ca. 1870-1930)
- Indian peculiarity: very low labor mobility today: caste-based rural insurance networks $\rightarrow$ job market frictions (Kaivan and Rosenzweig, 2016)
- The impact of influenza suggests Malthusian behavior (Donalson & Keniston, 2021)

$\longrightarrow$ Unique setting to study Malthusian conditions

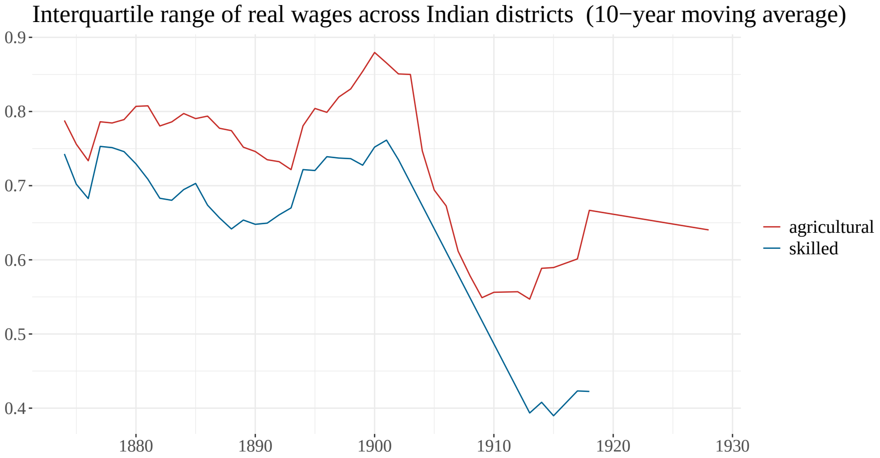
Indian aggregate trends: output stagnation and no industrialization

- Slow GDP increase (1.5 percent pc./y) absorbed by population growth (Roy, 2020), no agricultural productivity gains (Broadberry and Gupta, 2010)
- Constant labor share of agriculture, ca. 75 pc.: stagnation in agriculture dominates productivity gains in the industry and services.
- Living standards: stagnation in height while Britons got taller (Van Zanden et al., 2014), repeated famines
- Limited colonial state $\rightarrow$ insufficient investment in agricultural modernization (no 'green revolution')?

Fact 1. Income stagnation

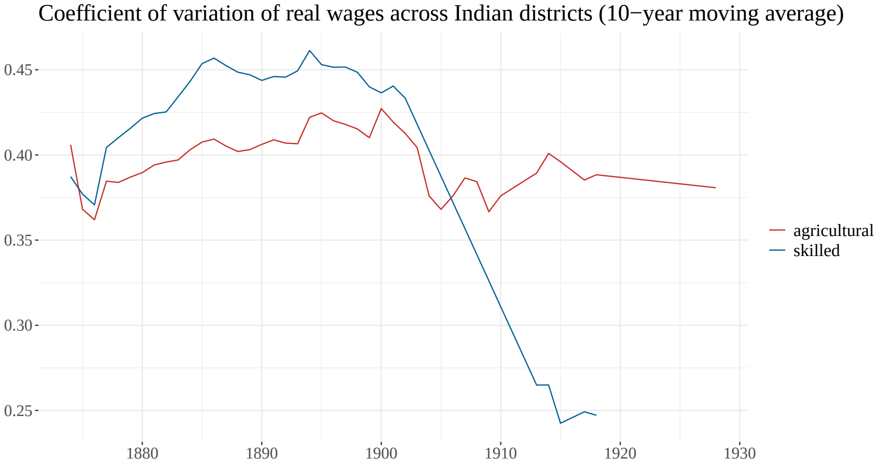


Fact 2. High, persistant regional income inequality



$$IQR_t = \frac{Q3_t - Q1_t}{Q1_t}$$

Fact 3. No agricultural σ-convergence over the period

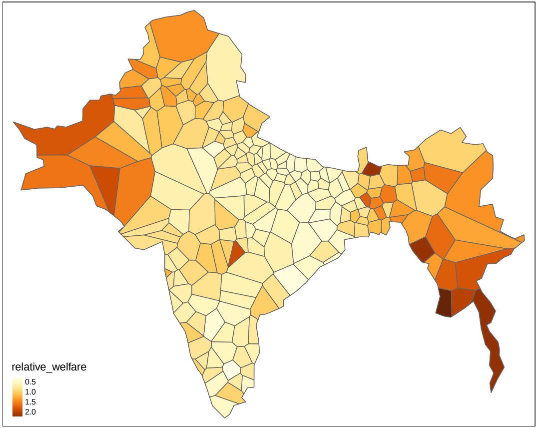


$$\text{cv}_t = \frac{\sigma_t}{\mu_t}$$

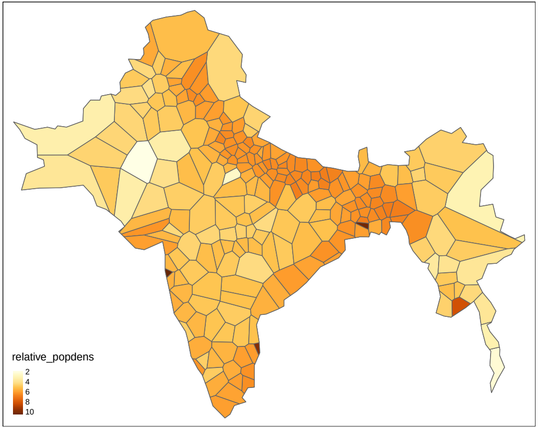
Fact 4: Trade-off between income and population density

Values aggregated over the whole time period

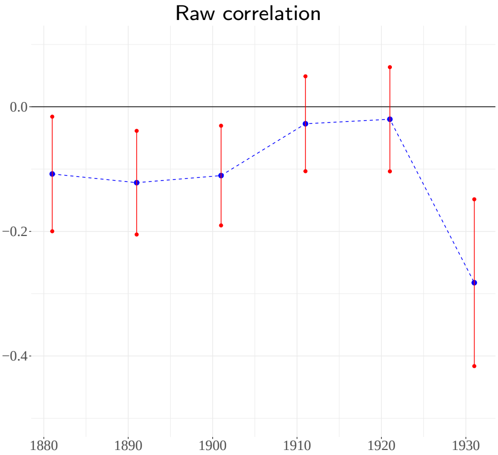
Agricultural income

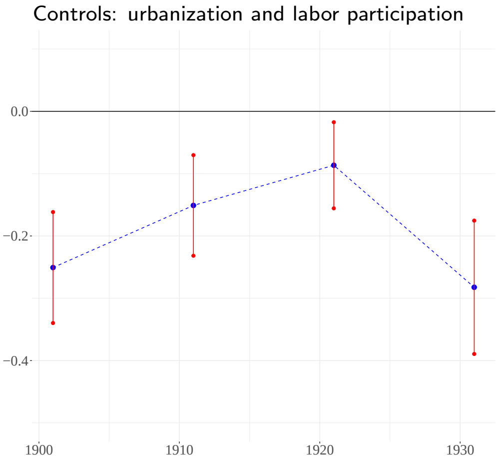


Population density



Evolution of the correlation between population density and agricultural income





What I do

1. I generalize the Malthusian model, including migration, to generate a whole range of demographic responses

2. A novel panel of local subsistence ratios (real wages) for colonial South Asia

3. Based on 1. and 2., test the strength of:
    - Malthusian constraint on income
    - Malthusian demographic behavior
    - Income elasticity of migration/sectoral mobility

What I find

1. Theory: Malthusian features counteract the income convergence effect of labor mobility
2. Malthusian constraint and dynamics of income and population in colonial India
3. Weak Malthusian demographic behavior
4. Some β-convergence, but to different steady-states!
5. Low labor mobility $\rightarrow$ no convergence between regions

Contribution to the literature

- **Growth literature on Malthusian economies**: Ashraf and Galor (2011), Moller and Sharp (2014), Nicolini (2007), Chiarini (2010), Cummins (2020), Pedersen et al. (2021), Donaldson and Keniston (2021).

$\longrightarrow$ Generalized Malthusian model, estimated in a panel setting

- **Interregional and intersectoral labor mobility**. Papers on India: Tumbe (2012), Tumbe (2015), Munshi and Rosenzweig (2016), Fenske et al., (2022).

$\longrightarrow$ Consider the effect of labor migrations in a Malthusian economy

- **Historical income measurement**. Papers on South Asia: Broadberry and Gupta (2006), Allen (2007), Broadberry et al., (2015), De Zwart and Lucassen (2020).

$\longrightarrow$ Measure historical subsistence ratios at the local level

Model

- Standard Malthusian model (Ashraf & Galor, 2011):
    1. Malthusian constraint: fixed factor $\rightarrow$ income-population density trade-off
    2. Malthusian population response: linear cost of children $\rightarrow$ population growth linear in income

- Standard fertility transition model (Quantity-Quality, UGT):
    - ▷ Overcoming the subsistence constraint makes it possible to substitute quality for quantity $\rightarrow$ population growth becomes independent of income

- This paper: demographic behavior includes
    - ▷ endogenous mortality
    - ▷ endogenous migration (definitive or temporary)
    - ▷ endogenous fertility

$\Longrightarrow$ Fully flexible population response to income (not necessarily linear, possibly non- or anti-Malthusian), without reference to quality

Malthusian constraint

Standard Malthusian production (Ashraf & Galor, 2011) using labor L and fixed land X:

- In district i and time t, $Y_{it} = (A_{it}X_i)^{\alpha} L_{it}^{1-\alpha}$
- Income per capita decreases in population density:

$$y_{it} = \left(\frac{A_{it}}{P_{it}}\right)^{\alpha}$$

Mortality

- Agents live for two periods, with probability d_{it} of dying between t and $t+1$.
- Mortality depends on health, which is log-linear in income and hit by a random shock σ:

$$h_{it} = h + \log y_{it} + \sigma_{it}$$

- σ_{it} follows an exponential distribution of rate λ, such that

$$d_{it} = \mathbb{P}(h_{it} < 0) = 1 - \left(\frac{y_{it}}{e^{-h}}\right)^{\lambda}$$

Labor migration

Between t and $t+1$, agents can also migrate to a high income region (or sector) h, defined by $y_{it} \leq y_{ht}$.

- Labor market frictions (eg. caste-related): job finding in the region of destination is a Poisson point process of rate η
- Risk-aversion: opportunity cost of migration τ increases exponentially in job search time T, with $\tau(T) = (e^{T} - 1)y_i$
- Probability of migration from region i to region h between t and $t+1$ writes

$$m_{it} = \mathbb{P}(y_{it} < y_{ht} - \tau_{it}) = 1 - \left(\frac{y_{it}}{y_{ht}}\right)^{\eta}$$

Fertility

- Household intertemporal isoelastic utility determines the number of children b_{it}, and thus the natural increase $n_{it} = b_{it}(1 - d_{it})$

$$u_{it} = \frac{1}{1-\theta_i}\left(\underbrace{\frac{y_{it}}{b_{it}^{1-\epsilon}}}_{\text{Present income p.c.}} \right)^{1-\theta_i} + \frac{\beta_i}{1-\theta_i}\left(\underbrace{n_{it} y_{i,t+1}}_{\text{Future total income}} \right)^{1-\theta_i}$$

  - ▷ $\epsilon > 0$ captures the decreasing marginal cost of children
  - ▷ Malthusian production: $y_{i,t+1} = \left[n_{it}(1 - m_{it})\right]^{-\alpha} y_{it}$
  - ▷ Conservative income expectation for migrants: $\mathbb{E}_{it}(y_{h,t+1}) = y_{i,t+1}$

- More children implies
  - ▷ less consumption today (although not necessarily linearly)
  - ▷ presumably more income tomorrow (but also higher mortality and lower productivity, moderated by higher migration)

Population response

- Population growth writes

$$\pi_{it} = n_{it}(1 - m_{it}) = \frac{\nu_i}{y_{ht}^{\eta}} y_{it}^{\gamma}$$

where

$$\gamma = \frac{(1-\epsilon)\lambda - \epsilon\eta}{\alpha - \epsilon}$$

  - ▷ Ashraf & Galor: $\epsilon = \eta = 0$, $\lambda = \alpha$

- Population response may or may not be Malthusian. With $\alpha > \epsilon$, Malthusian response ($\gamma > 0$) iff

$$\eta < \frac{1-\epsilon}{\epsilon}\lambda$$

  - ▷ health conditions are bad (large λ)
  - ▷ labor mobility is low (small η)
  - ▷ marginal cost of children not too decreasing (small ϵ)

Malthusian trap and β-convergence

- Malthusian response $\Longleftrightarrow$ Malthusian trap (stable steady-state $\pi_i = 1$)
  - ▷ Increasing labor mobility can trigger an escape from the Malthusian trap.
- Malthusian response ($\gamma > 0$) $\Longleftrightarrow$ Conditional β-convergence ($\frac{\partial g_{it}}{\partial y_{it}} < 0$)

$$\underbrace{g_{it} = \Delta \log y_{it}}_{\text{income growth}} = \alpha \left[\underbrace{\Delta \log A_{it}}_{\text{productivity growth}} - \underbrace{\gamma \log y_{it}}_{\beta\text{-convergence term}} + \underbrace{\eta \log y_{ht}}_{\text{labor mobility}} - \underbrace{\log(\nu_i)}_{\text{child preference}} \right]$$

  - ▷ However, convergence to different steady-states

The Malthusian income gap (1): small economy

- Assume the high income economy h is large compared to i, such that $L_{h,t+1} \approx n_{ht} L_t$
- With i and h at the steady-state:

$$\underbrace{\log y_h - \log y_i}_{\text{income gap with migration}} = \frac{(1-\epsilon)\lambda - \alpha\eta}{(1-\epsilon)\lambda - \epsilon\eta} \underbrace{(\log y_h - \log y_{i,\eta=0})}_{\text{income gap without migration}}$$

- Full convergence only for $\eta \geq \frac{(1-\epsilon)\lambda}{\alpha}$. Otherwise, non-zero steady-state income gap!
  - ▷ Larger $\lambda \implies$ weaker convergence. Malthusian demographic behavior counteracts the convergence effect of migration.

The Malthusian income gap (2): small economy & temporary migration

- Migrants go back in their home region to have children.
- Mortality and fertility now based on 'national income' $\upsilon_{it} = (1 - m_{i,t-1})y_{it} + m_{i,t-1}y_{ht}$
- Assuming $\mathbb{E}_{it}(\upsilon_{i,t+1}) = \upsilon_{it}$ for tractability, the steady-state writes

$$\underbrace{y_h - y_i}_{\text{income gap with migration}} = \underbrace{\left(\frac{y_h}{y_i}\right)^{\eta}}_{>1} \underbrace{(y_h - \upsilon_i)}_{\text{income gap without migration}}$$

▷ In a Malthusian system, temporary migration *impoverishes* non-migrants and increases the income gap.

The Malthusian income gap (3): multiple small economies

- Consider a continuum of economies indexed by $i \in [0,1]$ such that $\frac{\partial y_i}{\partial i} > 0$ and $\frac{\partial \nu_i}{\partial i} < 0$
- Lewisian setting: jobs only available in the city h, and $y_h = y_x$ with $x \in [0,1]$.
- For $i, j < x$,

$$\underbrace{\log y_j - \log y_i}_{\text{rural income gap}} = \underbrace{\frac{\alpha - \epsilon}{(1-\epsilon)\lambda - \epsilon\eta}}_{-\gamma} \underbrace{(\log \nu_i - \log \nu_j)}_{\text{child preference gap}}$$

  - ▷ For $i, j > x$, same with $\eta = 0$
  - ▷ The Malthusian constraint (α) amplifies the rural income gap
  - ▷ Malthusian demographic behavior (λ) reduces the rural income gap .

The Malthusian income gap (4): small economies, out of the steady-state

- Denote $G_t^{ij} = \log \frac{y_{jt}}{y_{it}}$ the income gap between i and j. Assume a constant differential rate of productivity growth $a_{ij} = \log \frac{A_{j,t+1}}{A_{jt}} - \log \frac{A_{i,t+1}}{A_{it}}$.
- The income gap follows the path

$$G_t^{ij} = (1 - \alpha\gamma)^t (G_0^{ij} - G_{ij}) + G_{ij}$$

where $G_{ij} = \frac{1}{\gamma}\left(a_{ij} - \log \frac{\nu_j}{\nu_i}\right)$.

  - ▷ Non-Malthusian population response ($\gamma \leq 0$): $\implies$ divergence
  - ▷ May be counteracted by a decreasing productivity growth gap

The Malthusian income gap (5): two-country (or two-sector)

- Take into account migration in the high income region: $L_{h,t+1} = n_{ht}L_{ht} + m_t n_{it} L_{it}$
- Assuming $\mathbb{E}_t(y_{t+1}) = y_t$ for tractability, and denoting $y = \frac{y_h}{y_i}$, $\nu = \frac{\nu_h}{\nu_i}$, $X = \frac{X_h}{X_i}$, $A = \frac{A_h}{A_i}$, the steady-state writes

$$\nu y^{\lambda+\eta} + \underbrace{(y^{\eta} - 1)\frac{y^{\frac{1}{\alpha}}}{AX}}_{\text{migration term} \geq 0} = 1$$

- Without migration, $y = \nu^{-\frac{1}{\lambda}}$. With migration, no convergence in the general case (only if $\nu_i = \nu_h$).
- A larger productivity gap increases the income gap
  - ▷ The Lewis model is not valid with Malthusian behavior: regeneration of surplus labor
  - ▷ But still $\frac{\partial L}{\partial A} > 0$: technology-driven structural change

N-region empirical model: migration

- Gravity framework: net migration from i to j writes

$$M_t^{ij} = \frac{L_{it} L_{jt}}{\phi_{ij}} \left(\mu_j \frac{y_{jt}^\eta}{\Omega_{it}} - \mu_i \frac{y_{it}^\eta}{\Omega_{jt}} \right)$$

with multilateral resistance $\Omega_{it} = \sum_k \frac{\mu_k L_{kt} y_{kt}^\eta}{\phi_{ik}}$

- Impose a star-network structure for tractability: $\log \phi_{ij} = \log \phi_i + \log \phi_j$

- The net migration rate from i rewrites

$$m_{it} = \frac{1}{L_{it}} \sum_j M_t^{ij} = 1 - \zeta_i \zeta_t y_{it}^\eta$$

Estimation framework (1): Malthusian dynamics

- The preceding framework defines a population response of the form $\pi_{it} = \pi_i \pi_t y_{it}^{\gamma}$.
- Assume district-invariant shock for productivity: $A_{it} = A_i \varepsilon_t$.
- Denoting $\tilde{x}_{it}$ the i- and t- within-transformation of $\log x_{it}$, the model predicts:

$$\tilde{y}_{it} = -\alpha \tilde{P}_{it} \qquad (1) \text{ (Malthusian constraint)}$$

$$\tilde{\pi}_{it} = \gamma \tilde{y}_{it} \qquad (2) \text{ (Population response)}$$

$$\tilde{y}_{i,t+1} = -\alpha(1-\alpha\gamma)\tilde{P}_{it} \qquad (3) \text{ (Malthusian dynamics)}$$

$$\tilde{P}_{i,t+1} = -\frac{1-\alpha\gamma}{\alpha}\tilde{y}_{it} \qquad (4) \text{ (Malthusian dynamics)}$$

$$\tilde{g}_{it} = -\alpha\gamma\tilde{y}_{it} \qquad (5) \text{ (Beta-convergence)}$$

Data

⟶ Level of analysis: **district** × **decade**. 80-200 districts, 4-7 decades.

- Real wages: standard 'welfare ratio' methodology (Allen, 2001: comparable CPI such that subsistence level = 1). Agricultural workers and skilled craftsmen.
  - ▷ Wage data from British surveys (Fenske, Gupta and Yuan, 2020). Prices from various sources.
  - ▷ Standard regional barebone consumption baskets, specified at the district level for rice-wheat preference.
  - ▷ Spatio-temporal interpolation of missing prices. Yet 70 pc. of the CPI is local.
  - ▷ Annual data, but not all years are available and annual variation may be misrecorded → **averaged over 10-year spans to match the census**.
- Sex-specific population data: Indian Census, conducted every ten year from 1871 to 1931 (Fenske, Kala & Wei, 2021), including urbanization.
- Cultivated areas and sector specific labor participation (Donaldson, 2018, Fenske, Gupta et al., 2022).

Data Appendix

Testing the Malthusian constraint: $\tilde{y}_{it} = -\alpha \tilde{P}_{it}$ (1)

$$\log \bar{y}_{i[\![t-4,t+5]\!]} = \beta \log p_{it} + \gamma \chi_{it} + \lambda_t + \mu_i + \epsilon_{it} \tag{1}$$

	Dependent variable:					
	log(agricultural_income)			log(skilled_income)		
	(1)	(2)	(3)	(4)	(5)	(6)
log(population density)	0.007	-0.720^{***}	-0.845^{***}	-0.456^{***}	-1.248^{***}	-1.322^{***}
	(0.117)	(0.224)	(0.233)	(0.167)	(0.171)	(0.173)
Urbanization	No	Yes	Yes	No	Yes	Yes
Labor participation	No	No	Yes	No	No	Yes
Decade & district FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	687	581	581	738	538	538
R^2	0.00001	0.047	0.094	0.045	0.145	0.153

Note: *p<0.1; **p<0.05; ***p<0.01
Standard errors clustered at the district level.

Testing the population response: $\log \tilde{\pi}_t = \gamma \tilde{y}_{it}$ (2)

$$\log \frac{\tilde{P}_{i,t+10}}{\tilde{P}_{it}} = \beta \log \bar{y}_{i[\![t,t+9]\!]} + \gamma \chi_{it} + \lambda_t + \mu_i + \epsilon_{it} \tag{2}$$

	Dependent variable:					
	log(population growth)					
	(1)	(2)	(3)	(4)	(5)	(6)
log(agricultural income)	0.066^{**}	0.080^{*}	0.089^{***}			
	(0.030)	(0.042)	(0.023)			
log(skilled income)				0.020	0.104^{*}	-0.009
				(0.046)	(0.053)	(0.030)
Population	No	No	Yes	No	No	Yes
Urbanization	No	Yes	Yes	No	Yes	Yes
Labor participation	No	No	Yes	No	No	Yes
Decade & district FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	445	287	287	409	265	265
R^2	0.021	0.033	0.708	0.001	0.043	0.672

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$
Standard errors clustered at the district level.

Testing the Malthusian dynamics: $\tilde{y}_{i,t+1} = -\alpha(1-\alpha\gamma)\tilde{P}_{it}$ (3)

$$\log \bar{y}_{i[\![t,t+9]\!]} = \beta \log p_{it} + \gamma\chi_{it} + \lambda_t + \mu_i + \epsilon_{it} \tag{3}$$

	Dependent variable:					
	log(agricultural_income)			log(skilled_income)		
	(1)	(2)	(3)	(4)	(5)	(6)
log(population density)	-0.104	-0.259^{*}	-0.144	-0.589^{***}	-1.088^{***}	-0.818^{***}
	(0.117)	(0.149)	(0.165)	(0.140)	(0.210)	(0.230)
Urbanization	No	Yes	Yes	No	Yes	Yes
Labor participation	No	No	Yes	No	No	Yes
Decade & district FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	664	476	476	609	436	436
R^2	0.002	0.011	0.035	0.065	0.123	0.195

Note: *p<0.1; **p<0.05; ***p<0.01
Standard errors clustered at the district level.

Testing the Malthusian dynamics: $\tilde{P}_{i,t+1} = -\frac{1-\alpha\gamma}{\alpha}\tilde{y}_{it}$ (4)

$$\log p_{it} = \beta \log \bar{y}_{i[\![t-9,t]\!]} + \gamma \chi_{it} + \lambda_t + \mu_i + \epsilon_{it} \quad (4)$$

	Dependent variable:					
	log(population density)					
	(1)	(2)	(3)	(4)	(5)	(6)
log(agricultural income)	-0.044^{**}	-0.053^{***}	-0.063^{***}			
	(0.020)	(0.017)	(0.018)			
log(skilled income)				-0.098^{***}	-0.115^{***}	-0.115^{***}
				(0.030)	(0.025)	(0.024)
Urbanization	No	Yes	Yes	No	Yes	Yes
Labor participation	No	No	Yes	No	No	Yes
Decade & district FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	780	581	581	738	538	538
R^2	0.011	0.054	0.091	0.045	0.160	0.213

Note: Standard errors clustered at the district level. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Testing β-convergence: $\tilde{g}_{it} = -\alpha\gamma\tilde{y}_{it}$ (5)

$$\log \frac{\bar{y}_{i[\![t+1,t+10]\!]}}{\bar{y}_{i[\![t-9,t]\!]}} = \beta \log \bar{y}_{i[\![t-9,t]\!]} + \gamma\chi_{it} + \lambda_t + \mu_i + \epsilon_{it} \tag{5}$$

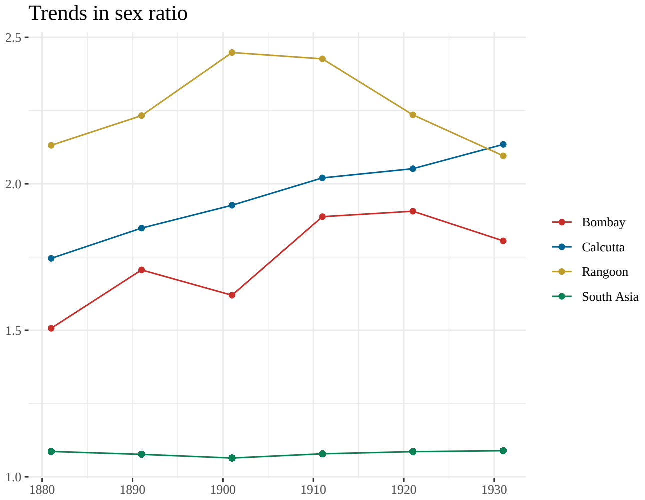
	Dependent variable:					
	log(agricultural income growth)			log(skilled income growth)		
	(1)	(2)	(3)	(4)	(5)	(6)
log(agricultural income)	-0.700^{***}	-1.404^{***}	-0.365^{***}			
	(0.079)	(0.090)	(0.048)			
log(skilled income)				-0.658^{***}	-1.131^{***}	-0.313^{***}
				(0.055)	(0.133)	(0.034)
Urbanization	No	Yes	Yes	No	Yes	Yes
Population, labor participation	No	No	Yes	No	No	Yes
Decade and district FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	550	301	301	540	284	284
R^2	0.339	0.732	0.297	0.300	0.437	0.276

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$
Standard errors clustered at the district level.

Malthusian dynamics: results

- Strong Malthusian constraint: 1 pc. increase in population density $\Longleftrightarrow$ 1 pc. decrease in income
- The population response is Malthusian, weakly though ($\gamma = 0.08$, not 1 as assumed by Ashraf & Galor !).
- β-convergence rate pf 3.5% $=$ 20 years to close half of the initial log gap *with the steady-state*
- Dynamics and beta-convergence: expected signs, non-consistent sizes: missing productivity shocks + biased FE estimator

Estimation framework (2): labor mobility



- From colonial to recent times, internal labor migration is male in India (Tumbe, 2012 and 2015)
- Female migration = marriage market
- Use this pattern to estimate η without migration data

Estimation framework (2): labor mobility

- Assumption: only male migration is responsive to male wage differentials
- Denoting σ_{it} the sex ratio of the non-migrant population,

$$\begin{cases} L^f_{i,t+1} = \frac{1}{1+\sigma_{i,t+1}} n_{it}\zeta^f_i \zeta^f_t L_{it} \\ L^m_{i,t+1} = \frac{\sigma_{i,t+1}}{1+\sigma_{i,t+1}} n_{it}\zeta^m_i \zeta^m_t y^\eta_{it} L_{it} \end{cases}$$

- Denoting $\Sigma_{it} = \frac{L^m_{it}}{L^f_{it}}$ the overall sex-ratio, and assuming $\sigma_{it} = \sigma_t \sigma_i$, where σ_i captures persistant local gender norms (Fenske et al., 2022),

$$\tilde{\Sigma}_{i,t+1} = \eta \tilde{y}_{it}$$

Estimation of labor mobility: $\tilde{\Sigma}_{it} = \eta \tilde{y}_{it}$.

$$\log \frac{P^m_{it}}{P^f_{it}} = \beta \log \bar{y}_{i[\![t-9,t]\!]} + \gamma \chi_{it} + \lambda_t + \mu_i + \epsilon_{it}$$

	Dependent variable:					
	log(sex ratio)					
	(1)	(2)	(3)	(4)	(5)	(6)
log(agricultural income)	0.018***	0.013***	0.014***			
	(0.005)	(0.004)	(0.004)			
log(skilled income)				0.023***	0.021***	0.022***
				(0.006)	(0.004)	(0.005)
Urbanization	No	Yes	Yes	No	Yes	Yes
Labor participation	No	No	Yes	No	No	Yes
Population	No	Yes	Yes	No	Yes	Yes
Decade & district FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	777	581	581	735	538	538
R^2	0.027	0.059	0.069	0.033	0.092	0.097

Note: *p<0.1; **p<0.05; ***p<0.01
Standard errors clustered at the district level.

Moving out of agriculture to the services?

$$\log P_{it}^{m,s} = \beta \log \bar{y}_{i[\![t-9,t]\!]} + \delta P_{it}^{f} + \gamma \chi_{it} + \lambda_t + \mu_i + \epsilon_{it}$$

	Dependent variable is the male workforce in each sector:					
	log(agricultural male pop)		log(industrial male pop)		log(services male pop)	
	(1)	(2)	(3)	(4)	(5)	(6)
log(agricultural income)	-0.049^{*}	0.012	-0.052	-0.005	0.054	0.061^{*}
	(0.025)	(0.019)	(0.035)	(0.035)	(0.036)	(0.036)
Urbanization and Female pop.	Yes	Yes	Yes	Yes	Yes	Yes
Labor participation	No	Yes	No	Yes	No	Yes
Decade & district FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	581	581	581	581	581	581
R^2	0.277	0.545	0.102	0.177	0.082	0.084

Note: *p<0.1; **p<0.05; ***p<0.01
Standard errors clustered at the district level.

The pull factor is restricted to the industry and the services.

$$\log P_{it}^{m,s} = \beta \log \bar{y}_{i[\![t-9,t]\!]} + \delta P_{it}^{f} + \gamma \chi_{it} + \lambda_t + \mu_i + \epsilon_{it}$$

	Dependent variable is the male workforce in each sector:					
	log(agricultural male pop)		log(industrial male pop)		log(services male pop)	
	(1)	(2)	(3)	(4)	(5)	(6)
log(skilled income)	-0.011	0.023	0.128**	0.163***	0.098**	0.097*
	(0.036)	(0.030)	(0.050)	(0.045)	(0.049)	(0.050)
Urbanization and Female pop.	Yes	Yes	Yes	Yes	Yes	Yes
Labor participation	No	Yes	No	Yes	No	Yes
Decade & district FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	538	538	538	538	538	538
R^2	0.246	0.518	0.110	0.233	0.094	0.094

Note: *p<0.1; **p<0.05; ***p<0.01
Standard errors clustered at the district level.

Take-out

- In an agricultural economy, children represent a cost for today but also an asset for tomorrow: the "Malthusian" population response is a particular case.
- Malthusian features are an additional barrier to income convergence and counteract the effect of labor mobility.
- Colonia India: Malthusian constraint, weak Malthusian demographic behavior, but even weaker labor mobility: no convergence.
- Future improvements
  - ▷ Refine the estimation of the Malthusian dynamics with weather shocks for A_{it} + unbiased estimator (Arellano-Bond?)
  - ▷ Refine the estimation of labor mobility with age-specific sex-ratio
  - ▷ Effect of famines on labor mobility

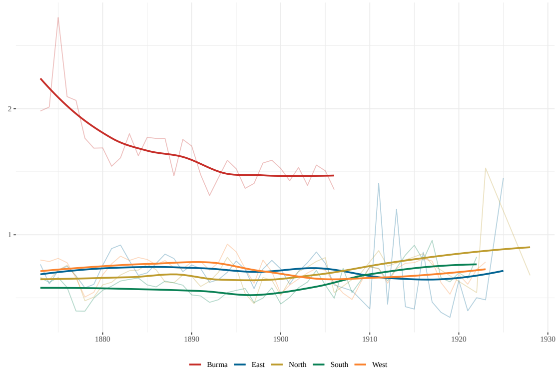
6. Appendix

Appendix

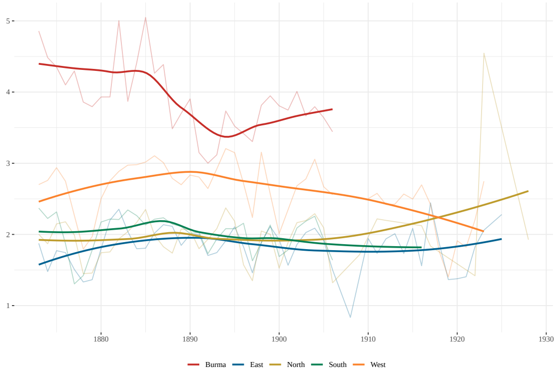
Regional trends in subsistence ratios

More on Burma

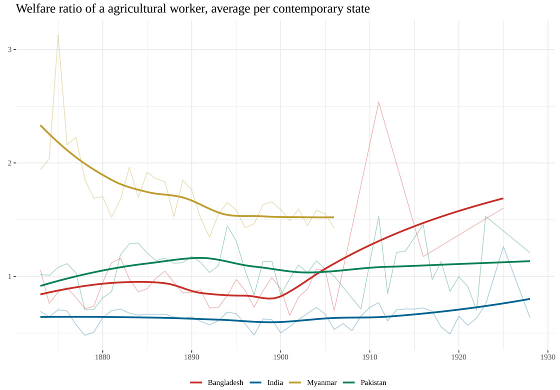
Welfare ratio of an agricultural worker, average per region

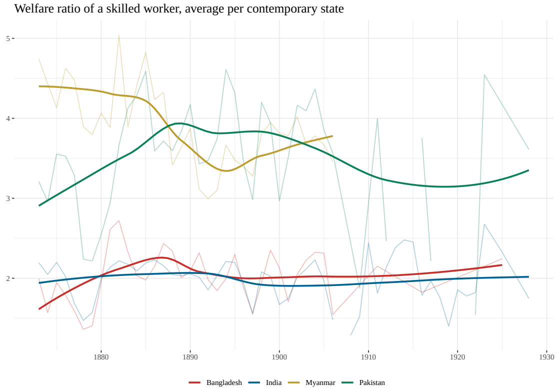


Welfare ratio of a skilled worker, average per region

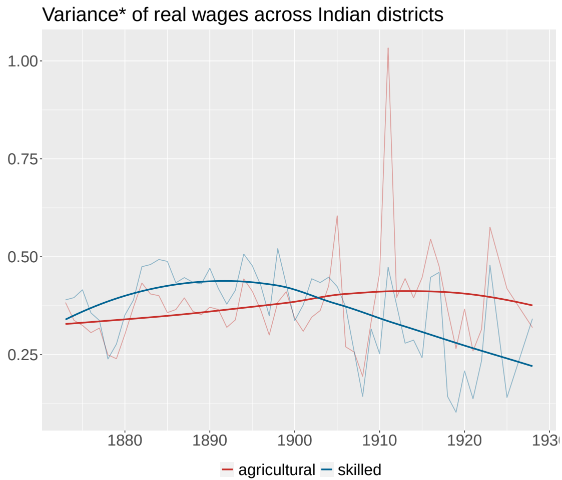


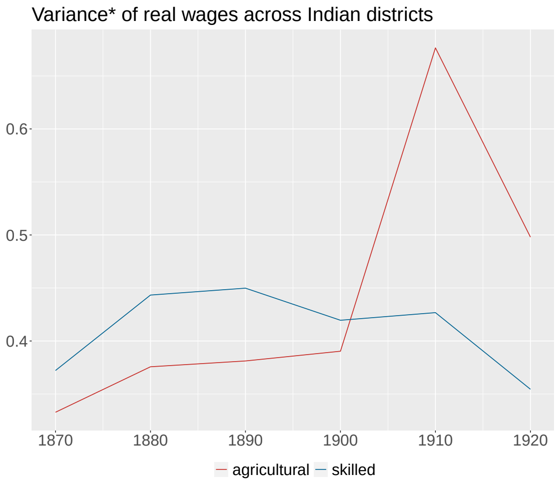
Modern state trends in subsistence ratios





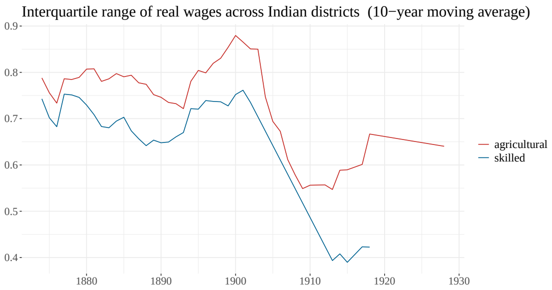
Absence of income convergence? (1)

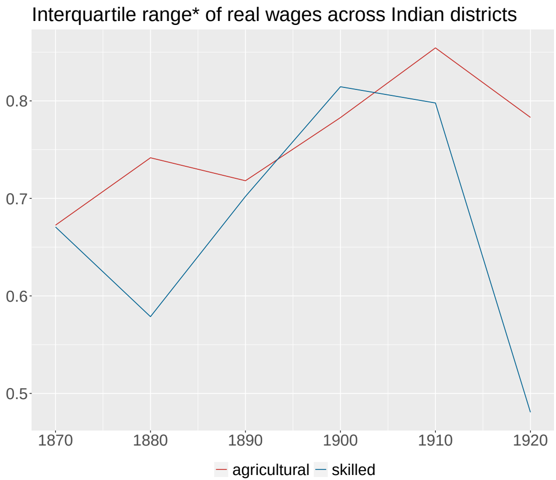




*Annual/decadal standard deviation in the cross-section normalized by the mean

Absence of income convergence? (2)



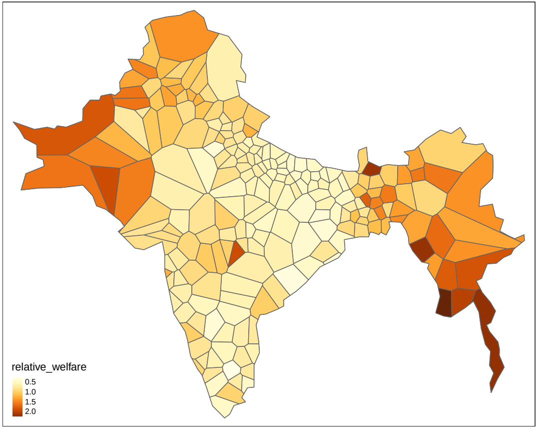


*Annual/decadal interquartile range in the cross-section normalized by the first quartile

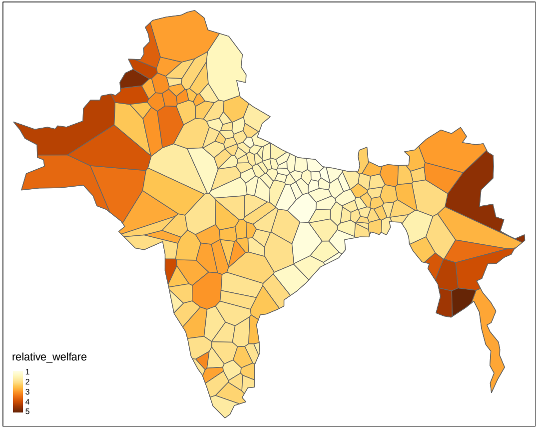
Local subsistence ratios, 1873-1928

Rescaled average relative income over the period: $w_d = \frac{\bar{w}}{T} \sum_1^T \frac{w_{dt}}{\bar{w}_t}$

Agricultural laborer

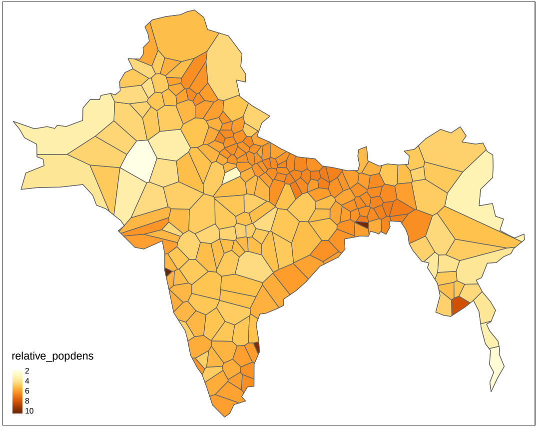


Carpenter, Mason, Blacksmith

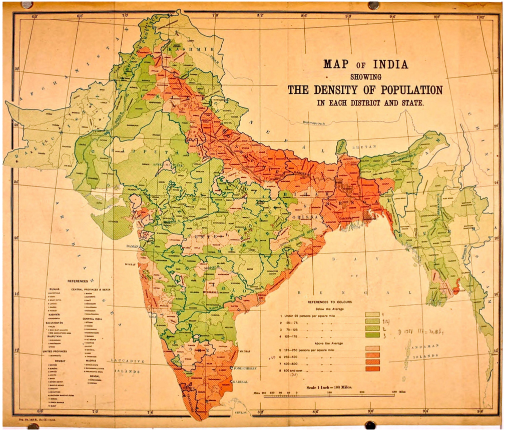


Population density: inverse the income map?

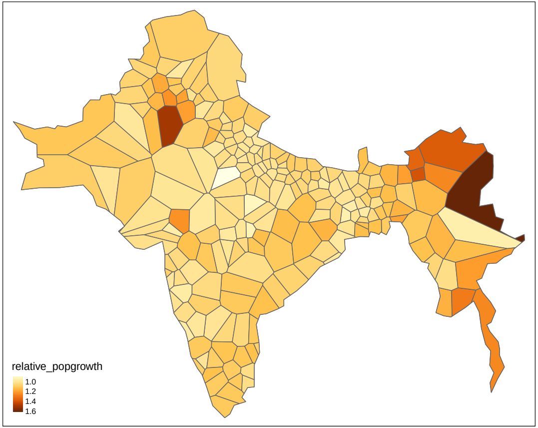
Average over the period



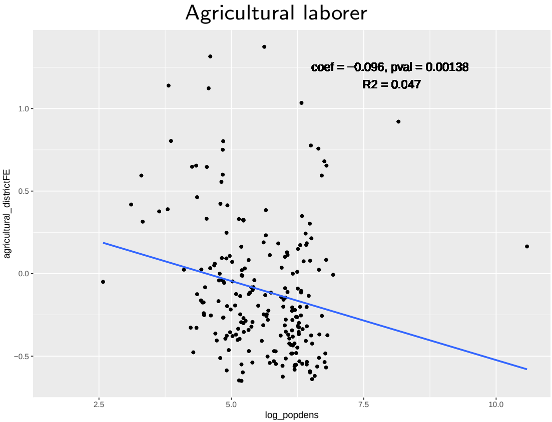
Census of 1901

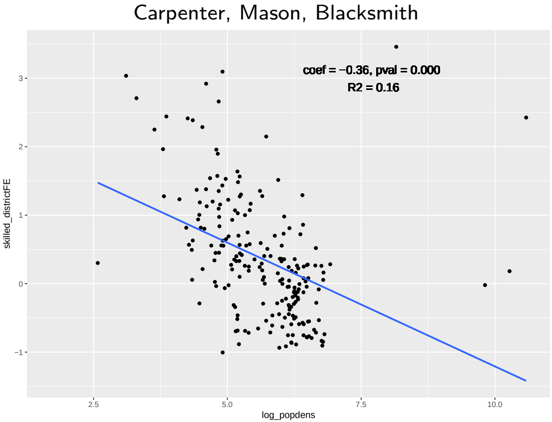


Population growth

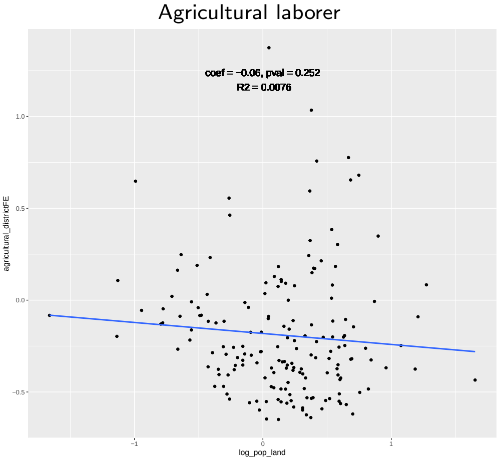


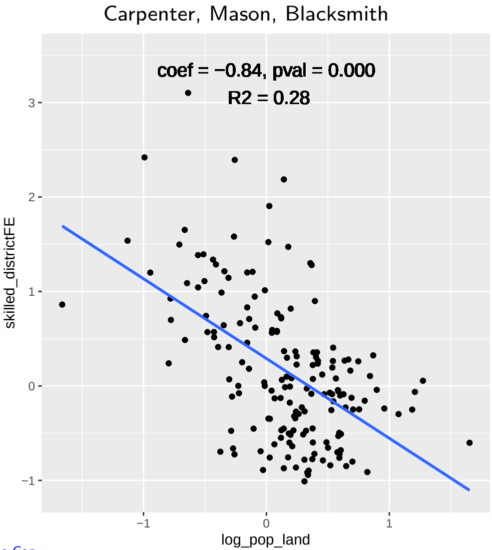
Income and population density, between districts



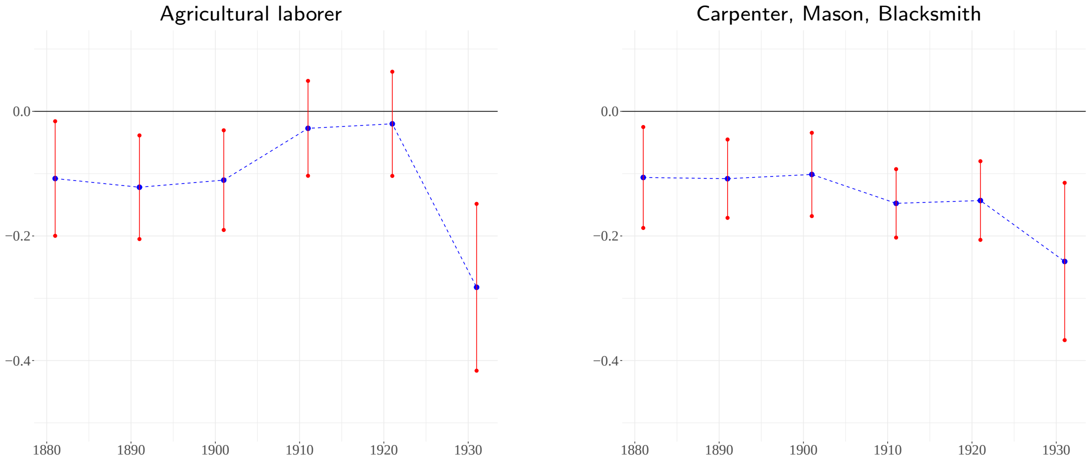


Income and population/land ratio, between districts Land data from Donaldson, 2018



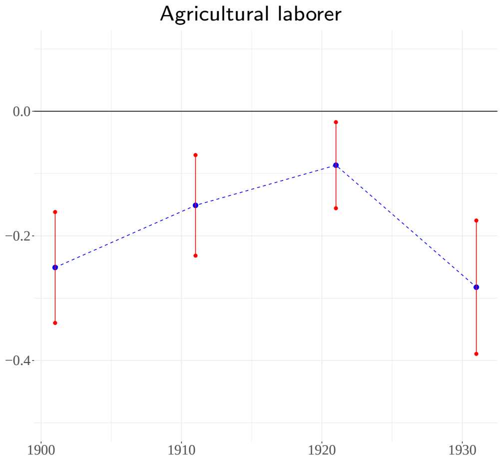


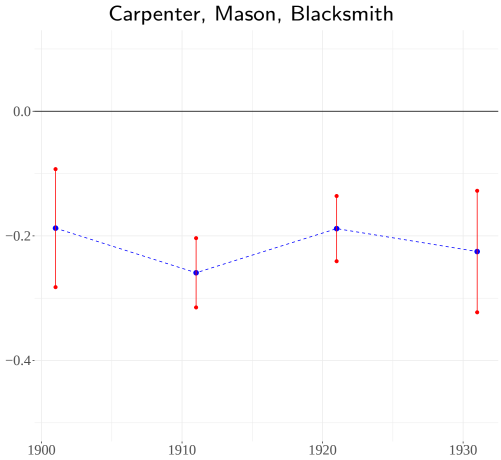
Evolution of the cross-sectional correlation between population and income



Evolution of the cross-sectional income/density correlation (with controls)

Control for labor participation to remove the demographic structure effects and for urbanization to stick to agricultural economies.





Wage data

- Two datasets collected by Fenske, Gupta and Yuan (2020): 80 districts for 1873-1906 (*Price and wages in India*), and then 194 districts with irregular observations between 1900 and 1928 (mostly quinquennial wage censuses).

- Roughly corresponds to two waves of statistical enquiry of uneven quality, the second one aiming to overcome the flaws of the first one.

  Owing to their unsatisfactory nature the half-yearly statements have been discontinued [...]. From 1911 a quinquennial wage census has been introduced in all provinces and this is expected to afford a more reliable source of information about wages than was possible before.

Report on the Enquiry into the Rise of Prices in India, 1915.

A critical assessment of wage data

Flaws in the first dataset (*Price and wages*) mentioned by the report:

- In-kind "supplements vary according to the season and the nature of the employment" (P&W) → potential urban bias in reporting cash wages
- Worked days issues due to the irregularity of employment
- Masons, carpenters and blacksmiths confused in an indistinct category
- Domestic servants represented by a minor profession (horsekeepers)

Quote:

- *The system of engaging and remunerating labour differs widely not only in different parts of India but* ***also in the same district****.*

A critical assessment of wage data

Compare the two datasets on their (small) intersection:

	Agricultural	Skilled*
Number of common observations (district year)	41	22
Mean($wage_2/wage_1$)	0.76	0.03
Correction applied to wage$_1$	0.8	0

Higher agricultural wages in the first dataset = likely due to urban bias → apply a conservative 20% downward correction

*In the remainder of this paper, skilled wage in dataset 2 = average of carpenters, masons and blacksmiths.

A critical assessment of wage data

Compare the correlation with an expected predictor of nominal wages: nominal (agricultural) production per capita. District level data for 1881-1930 based on Donaldson (2018) and Fenske Kala Wei (2021).

Let's run pooled OLS, between and individual FE model on four different panels:

1. The first dataset
2. The second dataset restricted to the districts present in the first dataset
3. The second dataset
4. The "final" panel obtained by merging (sometimes averaging) the two datasets

(District FE account for geographic factors driving local agricultural suitability. In all specifications, I remove non-agricultural districts by trimming).

Model:	*Dependent variable:*			
POOLED	log nominal agricultural wage			
	(1)	(2)	(3)	(4)
log nominal agricultural production per capita	0.234***	0.345***	0.403***	0.435***
	(0.021)	(0.070)	(0.033)	(0.017)
Observations	862	219	905	1,733
R^2	0.128	0.102	0.142	0.266

Model:	*Dependent variable:*			
BETWEEN	log nominal agricultural wage			
	(1)	(2)	(3)	(4)
log nominal agricultural production per capita	0.296***	0.388*	0.340***	0.410***
	(0.090)	(0.201)	(0.101)	(0.079)
Observations	49	45	172	176
R^2	0.185	0.079	0.062	0.135

Model:	*Dependent variable:*			
DISTRICT FE	log nominal agricultural wage			
	(1)	(2)	(3)	(4)
log nominal agricultural production per capita	0.019	0.578***	0.612***	0.497***
	(0.033)	(0.148)	(0.063)	(0.045)
Observations	862	219	905	1,733
R^2	0.001	0.304	0.319	0.263
Note:	*p<0.1; **p<0.05; ***p<0.01			

Dependent variable:			
log nominal skilled wage			
(1)	(2)	(3)	(4)
0.228***	0.359***	0.460***	0.371***
(0.023)	(0.097)	(0.046)	(0.020)
862	144	615	1,466
	0.104	0.089	0.138
0.193			

Dependent variable:			
log nominal skilled wage			
(1)	(2)	(3)	(4)
0.274***	0.365*	0.442***	0.407***
(0.094)	(0.195)	(0.095)	(0.073)
49	42	163	170
0.154	0.080	0.119	0.158

Dependent variable:			
log nominal skilled wage			
(1)	(2)	(3)	(4)
−0.011	0.369***	0.340***	0.244***
(0.038)	(0.085)	(0.048)	(0.046)
862	144	615	1,466
0.0003	0.084	0.093	0.091

A critical assessment of wage data: conclusion

- British surveyors indeed did a better job in the second wave.
- The first dataset does provide information on the variation between districts (pooled and between results). It is unreliable with regard to year-to-year variations at the district level (district FE results). Consistent with comments in the *Report*.
- This adds some noise to the merged panel, which nevertheless correlates well with production.

Conclusion:

1. Avoid using nominal wages from P&W to do district-year panel econometrics. In the next sections, I run OLS on district FE and panel regressions on 10-year averages.
2. Note that deflating by a CPI based on accurate price series may reintroduce relevant year-to-year variation (the same exercise on real variables yields less loss of correlation due to FE).

District-level CPI

- Framework: income ratios à la Allen, based on barebone consumption baskets.
- Allen (2007), Zwart Lucassen (2020): macro-regional consumption baskets (rice-based basket versus wheat/millet/sorghum-based basket).
- In the absence of district-level consumption data, I use the local cropped areas of rice and wheat (Fenske Gupta Yuan 2020) to weight locally the rice and the wheat basket and capture the continuum of consumption patterns.

If district d is in a rice region,

$$CPI_d = a_d CPI_{d,rice} + (1 - a_d) CPI_{d,wheat}$$

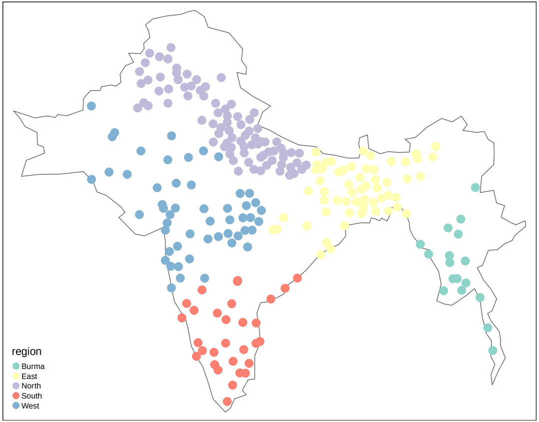
$$a_d = \frac{RiceArea_d}{RiceArea_d + WheatArea_d}$$

Regional barebone baskets Based on Allen (2007), Zwart Lucassen (2020), Bassino Van der Eng (2020)

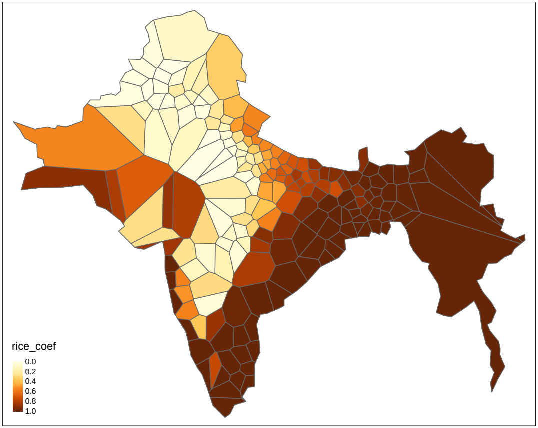
		North and West India	East India	South India	Burma
Rice	kg/year		162	164	164
Wheat	kg/year	57			
Millet	kg/year	60			
Sorghum	kg/year	60			
Peas	kg/year	20	30	28	28
Ghi	kg/year	3	3	3	
Cooking oil	liter/year				2.8
Sugar	kg/year	2	2	2	2
Salt	kg/year	2	2	2	2
Cotton	m^2/year	1.5	1.5	1.5	1.5
Lamp oil	liter/year	2.6	2.6	2.6	2.6
Fuel	MBTU/year	1	1	1	1
Calories	kcal/day	2007	2001	2001	2007
Protein	g/day	66	50	49	49

Refining local consumption baskets

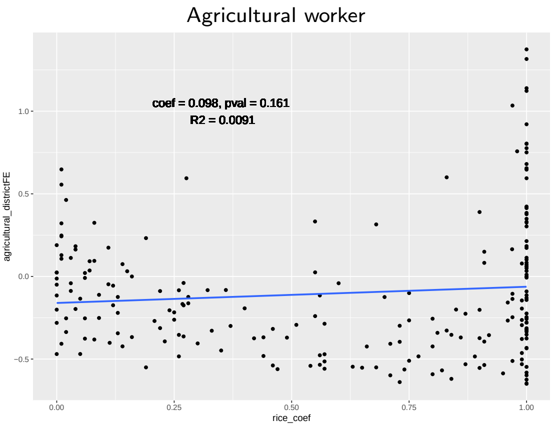
Macro-regions

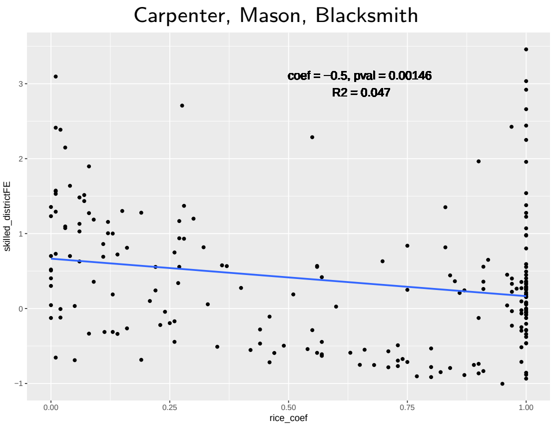


Rice versus wheat Data from Fenske, Gupta and Yuan, 2020.



Rice coefficient and income (district FE 1873-1928)

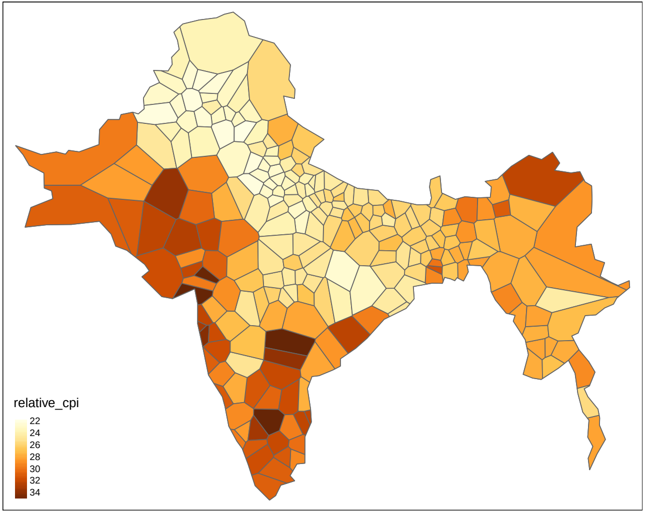




Handling missing values in local price data

- Local price series for cereals and salt in 206 markets for 1861-1921 collected by Fenske & Kala 2017 (still *Prices & Wages*) and regional price series for superior goods based on Allen 2007, Zwart & Lucassen 2020, Mukerjee 1945 and Bassino & Van der Eng 2020.
- 70% of the final CPI is based on local prices (including filled missing values).
  13805 missing values out of 60564 + 35 wage districts without recorded market.
- **To impute missing values, I use a standardized procedure of spatiotemporal interpolation**:
  1. If possible, use a substitute good in the same market-year.
  2. Interpolate (max 2 years).
  3. Use the same good in same year in the nearest market (max 1000 km).
  4. Use macro-regional series in last resort.
- To safeguard the consistency of price levels, each substitute value is rescaled with relative prices computed on the common available years for both price series.

CPI map



The Burmese exception (1)

- In terms of agricultural living standards, Burma compares to (Allen, 2007 or even overtakes (Nuvolari et al. 2019) Central and Southern European levels in the 19th century.
- Higher height (Bassino Coclanis 2008) and literacy (Figure **??**) too.
- High land/labor ratio, similarly to the rest of SE Asia. Burma was running a food surplus and was a major rice exporter (Kobayashi 2022).
- Labor migration to Burma (mostly Tamil and Bengali Muslim, Kim 2022). Rangoon as the main port for Indian immigrants around 1880, which induced some convergence in wages.

The Burmese exception (2)

> *Owing to high wages, and probably to this alone, the laboring classes are, upon the whole, well fed, clad, and housed...* **The Burmese peasantry are in more comfortable and easy circumstances than the masses of laboring poor in any of our Indian provinces; and making allowance for climate, manners, and habits, might bear a comparison with the peasantry of most European countries***.*

John Crawfurd, **1829**, Journal of an Embassy of the Governor-General of British India to the Court of Ava, 469. Cited by Bassino, in ed. Broadberry and Fukao 2021.

Testing the Malthusian model in the literature

There are four ways in the literature to test the Malthusian model:

- Test the steady-state predictions with cross-country regressions (eg. Ashraf & Galor, 2011)
- Test the short-run dynamics with time series in a single economy (eg. Moller & Sharp, 2014)
- Test the demographic behavior with individual-level regression (eg Cummins 2020)
- Study the outcomes of a plausibly exogenous population shock with DiD (eg. Donaldson & Keniston, 2021 on the 1918 influenza in India)

$\longrightarrow$ For the first time, let us estimate an 'extended' Malthusian dynamics in a panel setting.

Male population and income. $\log P^m_{it} = \beta \log \bar{y}_{i[\![t-9,t]\!]} + \delta P^f_{it} + \gamma \chi_{it} + \lambda_t + \mu_i + \epsilon_{it}$

Working only. Non-working only.

	Dependent variable:					
	log(male_population)					
	(1)	(2)	(3)	(4)	(5)	(6)
log(agricultural_income)	0.015***	0.010**	0.011***			
	(0.005)	(0.004)	(0.004)			
log(skilled_income)				0.015**	0.015***	0.016***
				(0.007)	(0.004)	(0.004)
Urbanization	No	Yes	Yes	No	Yes	Yes
Labor participation	No	No	Yes	No	No	Yes
Female population	Yes	Yes	Yes	Yes	Yes	Yes
Decade & district FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	777	581	581	735	538	538
R^2	0.933	0.930	0.930	0.929	0.930	0.930

Note: *p<0.1; **p<0.05; ***p<0.01
Standard errors clustered at the district level.

Robustness to influenza death rates (1)

Data from Fenske et al., 2022

	Dependent variable:	
	log(agricultural_income)	log(skilled_income)
	(1)	(2)
log(population density)	-0.283	-0.737^{***}
	(0.230)	(0.181)
log(1 + death_rate)	-0.805	-1.071^{**}
	(0.658)	(0.515)
Urban, LP, TWFE	Yes	Yes
Observations	490	468
R^2	0.021	0.087
Note:		*p<0.1; **p<0.05; ***p<0.01
		Standard errors clustered at the district level.

Robustness to influenza death rates (2)

Data from Fenske et al., 2022

	Dependent variable:	
	log(population growth)	
	(1)	(2)
log(agricultural_income)	0.011	
	(0.025)	
log(skilled_income)		0.018
		(0.028)
log(1 + death_rate)	−0.227	0.189
	(0.292)	(0.276)
Urban, LP, TWFE	Yes	Yes
Observations	352	344
R^2	0.041	0.068
Note:		$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$
		Standard errors clustered at the district level.

Robustness to influenza death rates (3)

Data from Fenske et al., 2022

	Dependent variable:	
	log(agricultural_income)	log(skilled_income)
	(1)	(2)
log(population density)	-0.159	-0.806^{***}
	(0.167)	(0.238)
log(1 + death_rate)	-0.296	0.240
	(0.851)	(0.824)
Urban, LP, TWFE	Yes	Yes
Observations	476	436
R^2	0.035	0.195
Note:		*p<0.1; **p<0.05; ***p<0.01
		Standard errors clustered at the district level.

Robustness to influenza death rates (4)

Data from Fenske et al., 2022

	Dependent variable:	
	log(population density)	
	(1)	(2)
log(agricultural_income)	-0.061^{***}	
	(0.018)	
log(skilled_income)		-0.110^{***}
		(0.024)
log(1 + death_rate)	-1.007^{***}	-0.888^{***}
	(0.170)	(0.169)
Urban, LP, TWFE	Yes	Yes
Observations	581	538
R^2	0.152	0.262
Note:	*p<0.1; **p<0.05; ***p<0.01	
	Standard errors clustered at the district level.	

Robustness to influenza death rates (sex ratio)

Data from Fenske et al., 2022

	Dependent variable:	
	log(population density)	
	(1)	(2)
log(skilled_income)	-0.110^{***}	-0.110^{***}
	(0.024)	(0.024)
log(1 + death_rate)	-0.888^{***}	-0.888^{***}
	(0.169)	(0.169)
Urban, LP, TWFE	Yes	Yes
Observations	538	538
R^2	0.262	0.262
Note:	*p<0.1; **p<0.05; ***p<0.01	
	Standard errors clustered at the district level.	

Robustness to influenza death rates (sectoral, 1)

Data from Fenske et al., 2022

	Dependent variable:					
	log(agri_ma)		log(indus_ma)		log(serv_ma)	
	(1)	(2)	(3)	(4)	(5)	(6)
log(agricultural_income)	-0.046^{*}	0.015	-0.053	-0.006	0.055	0.062^{*}
	(0.025)	(0.019)	(0.035)	(0.035)	(0.036)	(0.036)
log(1 + death_rate)	0.886^{***}	0.990^{***}	-0.243	-0.164	0.439	0.451
	(0.297)	(0.207)	(0.518)	(0.495)	(0.506)	(0.504)
LP	No	Yes	No	Yes	No	Yes
Urb., FP, TWFE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	581	581	581	581	581	581
R^2	0.291	0.562	0.102	0.177	0.084	0.085
Note:						$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$ Standard errors clustered at the district level.

Robustness to influenza death rates (sectoral, 2)

Data from Fenske et al., 2022

	Dependent variable:					
	log(agri_ma)		log(indus_ma)		log(serv_ma)	
	(1)	(2)	(3)	(4)	(5)	(6)
log(skilled_income)	−0.009	0.025	0.128^{**}	0.162^{***}	0.099^{**}	0.098^{*}
	(0.035)	(0.030)	(0.050)	(0.045)	(0.050)	(0.050)
log(1 + death_rate)	0.904^{***}	0.895^{***}	−0.103	−0.111	0.440	0.440
	(0.288)	(0.214)	(0.501)	(0.471)	(0.528)	(0.529)
LP	No	Yes	No	Yes	No	Yes
Urb., FP, TWFE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	538	538	538	538	538	538
R^2	0.262	0.533	0.110	0.233	0.096	0.096

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$
Standard errors clustered at the district level.

Male workforce and past income

	Dependent variable:					
	log(tot_ma)					
	(1)	(2)	(3)	(4)	(5)	(6)
log(agricultural_income)	−0.022	−0.029	0.021			
	(0.020)	(0.020)	(0.014)			
log(skilled_income)				0.022	0.024	0.052**
				(0.030)	(0.030)	(0.025)
Urbanization	No	Yes	Yes	No	Yes	Yes
Labor participation	No	No	Yes	No	No	Yes
Female population	Yes	Yes	Yes	Yes	Yes	Yes
Decade & district FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	581	581	581	538	538	538
R^2	0.283	0.336	0.611	0.275	0.316	0.597

Note: *p<0.1; **p<0.05; ***p<0.01
Standard errors clustered at the district level.

Placebo: non-working male population and past income

	Dependent variable:					
	log(nonw_ma_population)					
	(1)	(2)	(3)	(4)	(5)	(6)
log(agricultural_income)	0.049*	0.059**	−0.002			
	(0.030)	(0.029)	(0.021)			
log(skilled_income)				0.083*	0.071	0.035
				(0.047)	(0.048)	(0.047)
Urbanization	No	Yes	Yes	No	Yes	Yes
Labor participation	No	No	Yes	No	No	Yes
Female population	Yes	Yes	Yes	Yes	Yes	Yes
Decade & district FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	576	576	576	534	534	534
R^2	0.227	0.272	0.379	0.231	0.269	0.369

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$
Standard errors clustered at the district level.

Karl Marx in the New-York Herald Tribune 1853

Hindostan is an Italy of Asiatic dimensions, *the Himalayas for the Alps, the Plains of Bengal for the Plains of Lombardy, the Deccan for the Apennines, and the Isle of Ceylon for the Island of Sicily.* **The same rich variety in the products of the soil, and the same dismemberment in the political configuration**. *Just as Italy has, from time to time, been compressed by the conqueror's sword into different national masses, so do we find Hindostan, when not under the pressure of the Mohammedan, or the Mogul, or the Briton, dissolved into as many independent and conflicting States as it numbered towns, or even villages.* **Yet, in a social point of view, Hindostan is not the Italy, but the Ireland of the East. And this strange combination of Italy and of Ireland, of a world of voluptuousness and of a world of woes**, *is anticipated in the ancient traditions of the religion of Hindostan. That religion is at once a religion of sensualist exuberance, and a religion of self-torturing asceticism; a religion of the Lingam and of the juggernaut; the religion of the Monk, and of the Bayadere.*