Urbanization, Long-Run Growth, and the Demographic Transition

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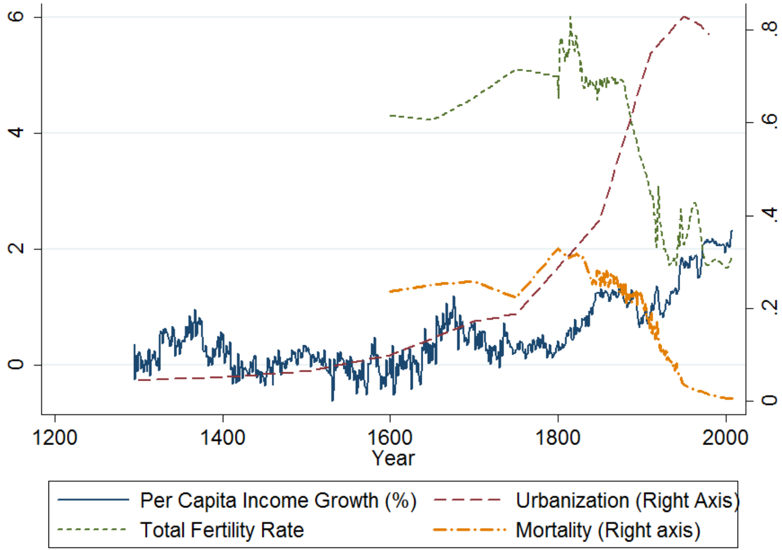
Three Transitions of Developing Economies

- **Growth Transition:** From near zero income growth to modern income growth
- **Demographic Transition:** Mortality and fertility are initially very high, then fall
- **Urbanization:** Economies are initially rural, then urbanize

Data

Three Transitions: England



Correlation of Transition Timing

	Income Growth	Urbanization	Fertility	Mortality
Income Growth	1			
Urbanization	0.518	1		
Fertility	0.542	0.393	1	
Mortality	0.608	0.467	0.881	1

Transition points: Growth $> 1\%$, Urb. $> 50\%$, TFR < 3, Child Mort. $< 5\%$

Current Cross-Section

	Urban $> 50\%$	TFR < 3	Child Mort. $< 5\%$
Income $>$ \$10K	93%	96%	97%
Income $<$ \$1K	7%	10%	13%

The Research Question

- Why do the three transitions occur around same time?
- Transitions simultaneously determined, complementary through standard mechanisms
- Contribution is to unify into a parsimonious growth model that endogenously generates all transitions
- A theory addressing all 3 transitions can predict: Declining wage gap, family size gap, early urbanization slows development

Related Literature

- **Economic Growth:** Becker and Barro (1988), Lucas (1988), *Becker Murphy and Tamura (1990)*, Galor and Weil (2000), Stokey (2001), *Hansen and Prescott (2002)*, Lucas (2002), Ngai and Pissarides (2007), Herrendorf et al (2013)
- **Urbanization:** Kuznets (1966), Maddison (1980), Williamson (1987), Bairoch (1991), *Lucas (2004)*, Clark (2009), Galor Moav and Vollrath (2009), Rauch and Redding (2012), Gollin Lagakos and Waugh (2014)
- **Demographic Transition:** Becker (1960), Preston (1996), *Galor and Weil (2000)*, Szreter and Hardy (2001), Fogel (2004), Deaton (2006), Becker et al (2010), Guinnane (2011)

Agenda

- Model
- Data (Simulation vs Actual)
- Cross-Country Implications

Model Setup

- Production has 2 sectors
- OLG, households choose quantity and quality of children
- Urban/rural location choice
- Endogenous growth

Production

Urban and rural productions functions. Firms choose human capital $\tilde{h}$ and land $\tilde{l}$.

$$F_R(\tilde{h}, \tilde{l}) = \tilde{h}^{\theta} \tilde{l}^{1-\theta} \tag{1}$$

$$F_U(\tilde{h}) = \tilde{h} \tag{2}$$

The final good is produced by combining the output of the urban and rural sectors, with elasticity of substitution ϵ:

$$F(\tilde{x_R}, \tilde{x_U}) = A(\zeta \tilde{x_U}^{\frac{\epsilon-1}{\epsilon}} + (1-\zeta)\tilde{x_R}^{\frac{\epsilon-1}{\epsilon}})^{\frac{\epsilon}{\epsilon-1}} \tag{3}$$

Final goods firms choose rural goods $\tilde{x_R}$ and urban goods $\tilde{x_U}$ as inputs. Require $\epsilon > 1$ (Ngai and Pissarides 2007, Acemoglu and Guerrieri 2008)

Firms

All sectors are competitive. Prices of rural and urban goods are p_R and p_U. Final good is numeraire. Rental rate of land is r, and rural and urban wages per unit of human capital are w_R and w_U. A rural firm solves:

$$\max_{\tilde{h},\tilde{l}} p_R \tilde{h}^\theta \tilde{l}^{1-\theta} - w_R \tilde{h} - r\tilde{l} \tag{4}$$

An urban firm solves:

$$\max_{\tilde{h}} p_U \tilde{h} - w_U \tilde{h} \tag{5}$$

And a final goods firm solves:

$$\max_{\tilde{x_R},\tilde{x_U}} A(\zeta \tilde{x_U}^{\frac{\epsilon-1}{\epsilon}} + (1-\zeta)\tilde{x_R}^{\frac{\epsilon-1}{\epsilon}})^{\frac{\epsilon}{\epsilon-1}} - p_R \tilde{x_R} - p_U \tilde{x_u} \tag{6}$$

Households

- Agents live for two periods: one as a child, and one as an adult. Each household consists of one adult and a number of children.
- The adults makes the household's decisions. They begin adulthood with human capital h, chosen by their parents. Then choose location.
- Households earn labor income, but do not own land. Assume all land held by a negligibly small fraction of population.
- Parents enjoy consumption c and surviving children n. They can invest in their children's human capital h'.

Utility Function

- Utility is dynastic: Enjoy present consumption c and children n, and dynasty's future discounted utility
- A dynasty discounting by β has utility:

$$V = u(c, n) + \beta V' \tag{7}$$

- Require balanced growth compatibility: will use $u(c, n) = \frac{(cn^{\phi})^{\sigma}}{\sigma}$ (Becker & Barro 1988)

Time Use

- Households allocate their time to market work τ_c, child-rearing τ_n, and educating children τ_h, s.t.:

$$\tau_c + \tau_n + \tau_h = 1 \tag{8}$$

- Households can spend income on consumption goods

- A parent in sector j earns wage w_j per unit of human capital, per unit of time worked, so that:

$$c = w_j h \tau_c \tag{9}$$

Child Production

- The household in sector j choosing τ_n produces n total children by:

$$n = S_j \alpha \tau_n \tag{10}$$

- α is parents' productivity in raising children
- Fraction S_j of children survive to adulthood, so fertility is $\frac{n}{S_j}$
- Child rearing is time intensive (no h, e.g. Becker & Barro 1988)

Human Capital Accumulation

- Children endowed with parents' human capital h
- Parents can spend time τ_h to increase children's human capital h'
- Must educate all children n, linear in τ_h and parental human capital h (simplified Becker, Murphy, & Tamura 1990):

$$(h' - h)n = \xi \tau_h h \tag{11}$$

- The parameter ξ is the productivity at producing human capital

Budget Constraint

- A parent in sector j with h human capital faces the combined budget constraint:

$$c + \frac{w_j(h' - h)n}{\xi} + \frac{w_j hn}{\alpha S_j} = w_j h \tag{12}$$

- And non-negativity constraints:

$$c \geq 0 \quad n \geq 0 \quad h' \geq h \tag{13}$$

Household's Problem

- A household with human capital h picks sector j and chooses (c, n, h') to maximize dynastic utility (7) subject to constraints (12) and (13) given wage w_j and survival S_j
- Prices w_j and S_j determine location preference ($w_j \rightarrow$ compensating differential)

First Order Conditions: General

$$u_n(c,n) = u_c(c,n)(\frac{w_j h'}{\xi} + \frac{w_j h}{\alpha S_j})$$

$$u_c(c,n) w_j n = \xi \beta V'(h'; \Lambda')$$

$$V'(h; \Lambda) = u_c(c,n) w_j (1 + \frac{n}{\xi} - \frac{n}{\alpha S_j})$$

First Order Conditions: Specialized

Cobb-Douglas utility implies consumption is constant share of income:

$$\frac{c}{w_j h} = \frac{1}{1+\phi} \tag{14}$$

The Euler equation holds for all children k:

$$\left(\frac{c'_k}{c}\right)^{1-\sigma} = \left(\frac{n'_k}{n}\right)^{\phi\sigma+1} \frac{w'_k}{w_j} \xi \beta \left(\frac{1}{n'_k} + \frac{1}{\xi} - \frac{1}{\alpha S'_k}\right) \tag{15}$$

Different children (indexed by k) share $V(h')$, but might make different location choices

Q-Q Intuition: Steady State Euler Equation

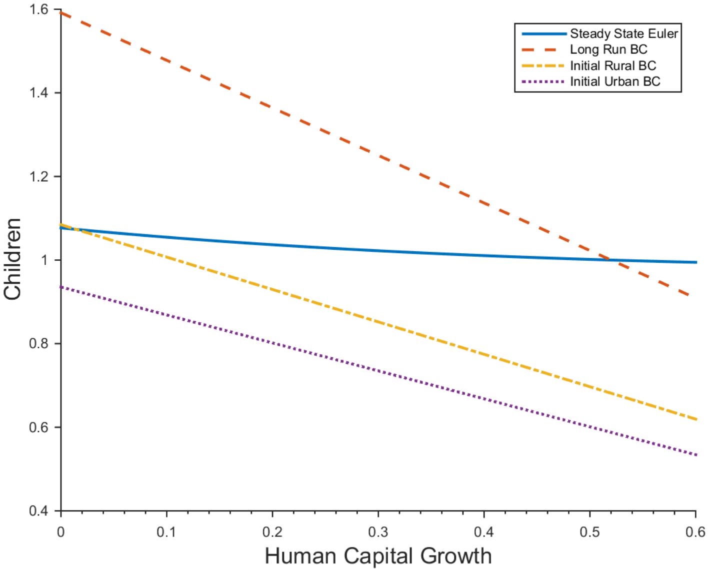
- Let g be the human capital growth rate. Then in SS:

$$(1+\bar{g})^{1-\sigma} = \beta\frac{\xi}{\bar{n}}(\tau_c + \bar{n}\frac{1+\bar{g}}{\xi}) \tag{16}$$

- $\tau_c + \bar{n}\frac{1+\bar{g}}{\xi}$ is the return to human capital

- $\frac{\xi}{\bar{n}}$ is the time cost of producing human capital

Q-Q Substitution: Steady State Comparison



Urban/Rural Differences

- All households indifferent, equal marginal value of human capital across locations ▸ Proof

- Returns to education equalized

$$w_R^{\sigma} n_R^{\sigma\phi+1}\left(\frac{1}{n_R} + \frac{1}{\xi} - \frac{1}{\alpha S_R}\right) = w_U^{\sigma} n_U^{\sigma\phi+1}\left(\frac{1}{n_U} + \frac{1}{\xi} - \frac{1}{\alpha S_U}\right) \qquad (17)$$

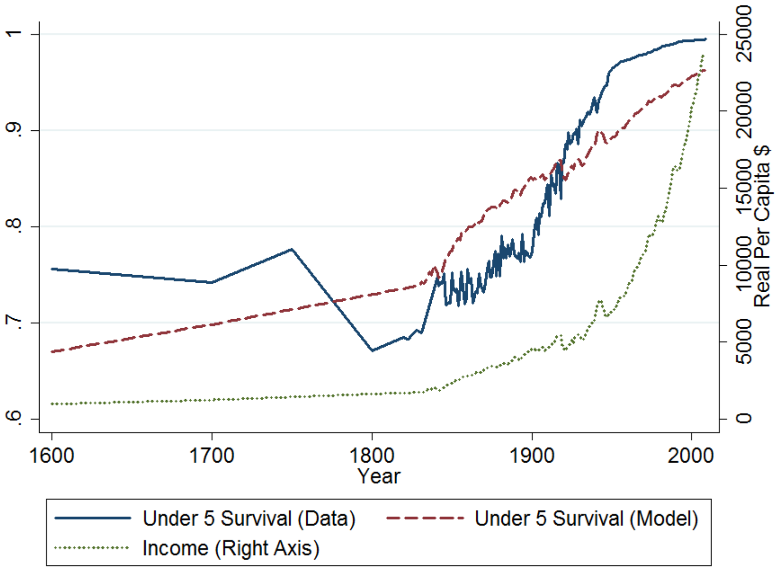
- Wage premium increasing in $\frac{n_R}{n_U}$

Child Survival Function

- Child survival is a function of location j and average human capital $\bar{h} \equiv \sum_h \frac{h\lambda(h)}{N}$
- This function should have three properties:
    - $S_j(\bar{h}_0)$ matches an empirical target for each j
    - $S_j'(\bar{h}) > 0$ for all $\bar{h} \geq \bar{h}_0$
    - $S_j(\infty) = \bar{S}$, matching a modern empirical target
- A flexible form satisfying these properties is:

$$S_j(\bar{h}) = \bar{S} - (\bar{S} - S_{j,0})\frac{1 + \upsilon\bar{h}_0}{1 + \upsilon\bar{h}} \tag{18}$$

UK Estimated Survival Function



Aggregates

The state of the economy is determined by the function $\lambda(h)$, which denotes the number households with human capital h.

- The total population in the economy N is:

$$N = \sum_h \lambda(h) \tag{19}$$

- $\lambda(h, j)$ is the number of (h, j) households. Aggregate human capital inputs:

$$H_j = \sum_h \frac{h\lambda(h, j)}{1 + \phi} \tag{20}$$

- For factor prices w_U, w_R, r and land L, total income in the economy is:

$$Y = w_U H_U + w_R H_R + rL \tag{21}$$

Aggregate Law of Motion

Let $n(h,j)$ and $d(h,j)$ denote the child and education choices of a household with human capital h in sector j. Rewrite human capital accumulation as function:

$$h'(h;j,Z) = \xi d(h,j) \tag{22}$$

Let $h(h';j,Z)$ denote the inverse of this function. The distribution of households evolves by:

$$\lambda(h') = \sum_j n(h(h';j,Z),j)\lambda(h(h';j,Z),j) \tag{23}$$

Equilibrium Definition

A competitive equilibrium in this economy consists of sequences of prices, p_R, p_U, w_R, w_U, r; aggregate allocations, $Y, x_U, x_R, H_U, H_R, \bar{h}$; distribution of household human capital $\lambda(h, j)$; and household allocations, $c(h, j), d(h, j), n(h, j)$; given initial distribution of human capital $\lambda(h)_0$ and the aggregate quantity of land L, such that:

1. The firm allocations solve (4), (5), and (6).
2. The household choose location and allocations to maximize (7) subject to (12) and (11)
3. Markets clear: $Y = F(x_U, x_R)$, $X_U = F_U(H_U)$, $X_R = F_R(H_R)$
4. The law of motion (23) holds for all human capital levels.
5. Household aggregates add up, satisfying equations (19), (20), and (21).

Equilibrium Prices

The firms' profit maximization implies that equilibrium prices must relate to equilibrium factors by:

$$w_U = p_U \qquad w_R = p_R \theta (H_R)^{\theta-1} L^{1-\theta} \qquad r = p_R (1-\theta)(H_R)^{\theta} L^{-\theta} \tag{24}$$

$$p_U = A^{\frac{\epsilon-1}{\epsilon}} \zeta \left(\frac{Y}{x_U} \right)^{\frac{1}{\epsilon}} \qquad p_R = A^{\frac{\epsilon-1}{\epsilon}} (1-\zeta) \left(\frac{Y}{x_R} \right)^{\frac{1}{\epsilon}} \tag{25}$$

Equilibrium in the Limit

- If $\lim_{t\to\infty} h_j = \infty$ for all households j, then $wh_j \to \infty$ and $\bar{h} \to \infty$.
- If $\sigma > 0$, limiting population growth is

$$n(h,j) \to \bar{n} \tag{26}$$

- Urban/rural wage premium is $\frac{w_U}{w_R} \to 1$.
- If $\epsilon > 1$, then the long-run urban share converges to 1 and the limit of both urban and rural wages is $\bar{w} \equiv A\zeta^{\frac{\epsilon-1}{\epsilon}}$.
- The long-run technological growth rate is $\frac{\bar{h}'}{\bar{h}} \to 1 + \bar{\mu} \equiv \xi \bar{w}(\frac{\phi}{\bar{n}(1+\phi)} - \frac{1}{\alpha \bar{S}})$

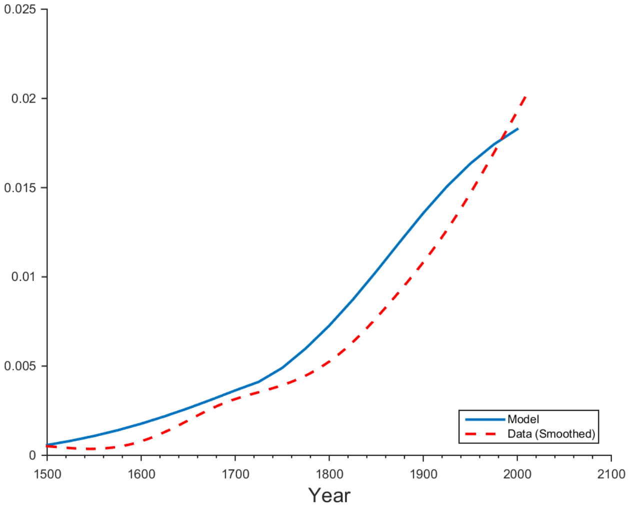
Calibration

- Calibrate initial condition to resemble England in 1500 C.E., then simulate.
- Choose some parameters to match empirical targets: $(A, \zeta, \epsilon, \theta, \alpha, \xi, \sigma, \phi, \beta)$
- Estimate ω and υ from mortality and income data.
- Target constant long run population, 5% long run interest rate
- One period is 25 years

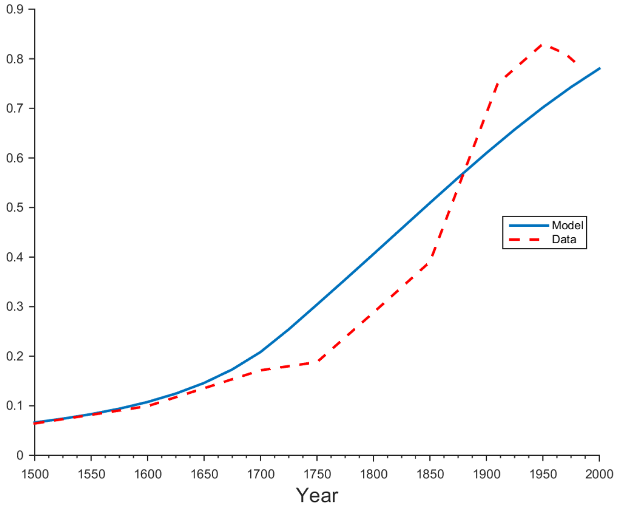
Empirical Targets

	Target	Empirical Value	Source
(i)	Land Share in Agriculture	0.260	Clark (2010)
(ii)	Initial Survival Probabilities	$S_{R,0} = 0.681, S_{U,0} = 0.543$	Clark (2009)
(iii)	Urban/Rural Surviving Child Ratio	$n_{U,0}/n_{R,0} = 0.771$	Clark (2009)
(iv)	Initial 25-year Population Growth	1.085	Broadberry et al (2010)
(v)	Initial 25-year Human Cap. Growth	1.013	Bolt and van Zanden (2013)
(vi)	Long-Run 25-year Human Cap. Growth	1.520	Bolt and van Zanden (2013)
(vii)	Initial Urban Share	0.064	Bairoch et al (1988)

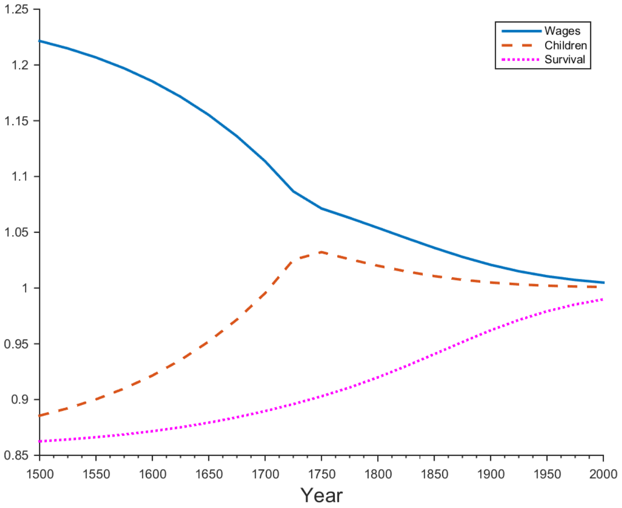
Annualized GDP Per Capita Growth Rates



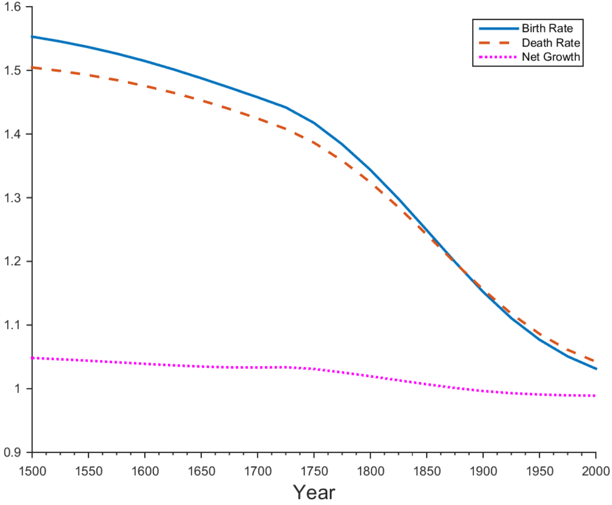
Urbanization



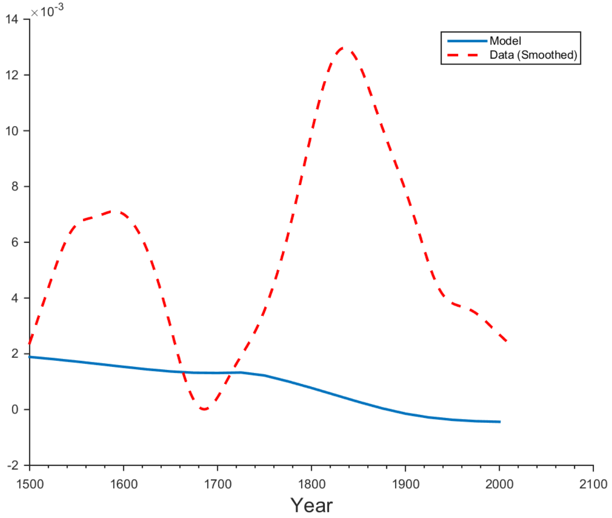
Urban/Rural Ratios



Demographic Transition

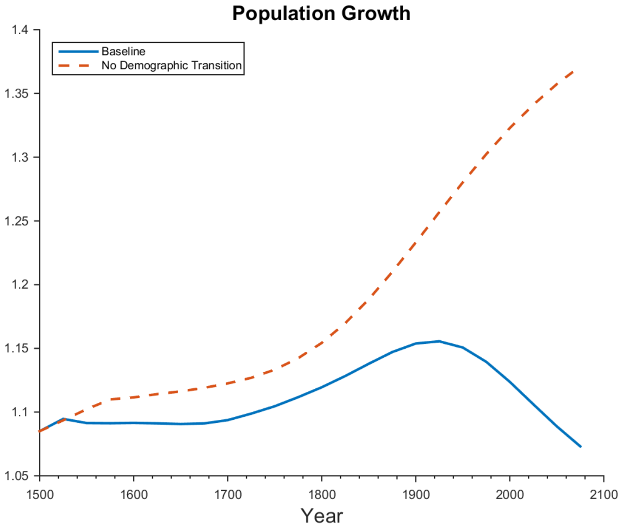


Annualized Population Growth Rates



No Demographic Transition

- Fix urban and rural fertilities $\frac{n_j}{S_j}$ at initial level
- Average fertility still falls, because of urbanization
- Q-Q substitution *over time* is shut down so get much less human capital growth


Population Growth
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No Demographic Transition
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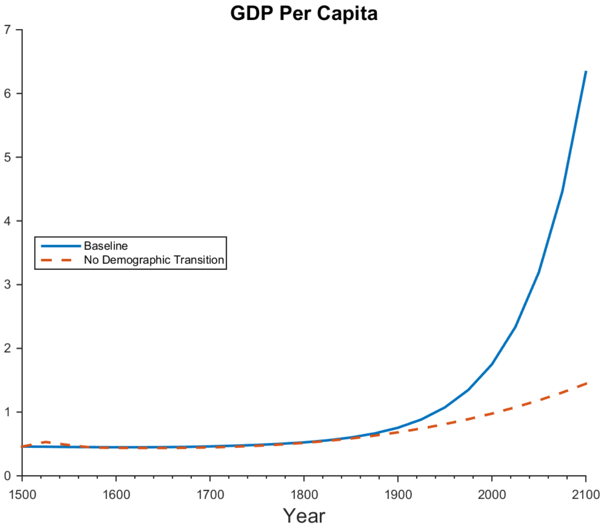
Year


GDP Per Capita
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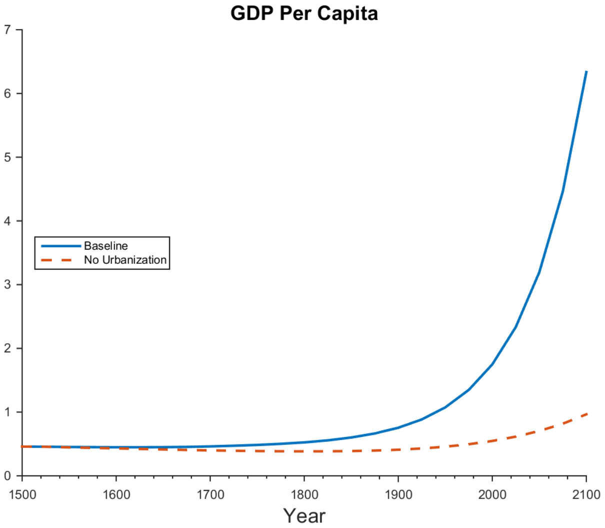
6
5
4
3
2
1
0
Baseline
No Demographic Transition
1500
1600
1700
1800
1900
2000
2100
Year

No urbanization

- Fix urban share at initial level
- Still have some migration (rural population growth is higher)
- Q-Q substitution *over space* is shut down
- Less human capital growth, more population growth more misallocation


GDP Per Capita
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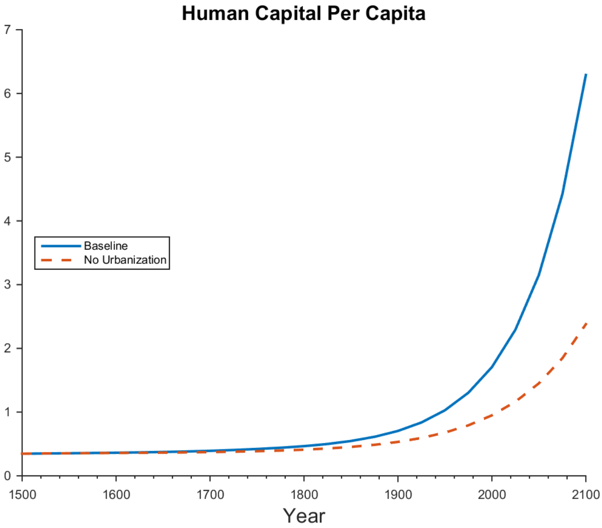
Baseline
No Urbanization


Human Capital Per Capita
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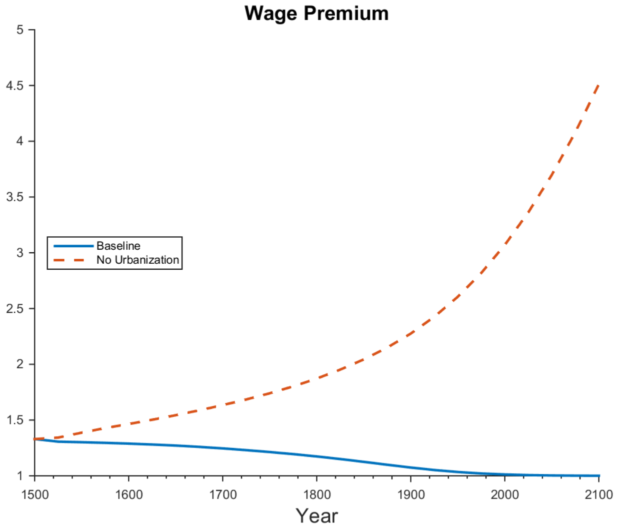
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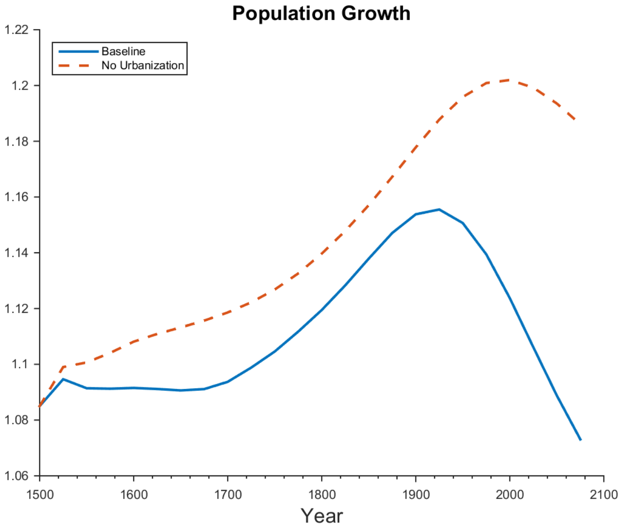
Baseline
No Urbanization


Population Growth
Baseline
No Urbanization
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1.14
1.12
1.1
1.08
1.06
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1900
2000
2100
Year

Conclusions and Next Steps

- Transitions are fundamentally connected
- When mechanisms are formalized in an endogenous growth model, can reproduce England's experience
- Miss important dynamics without all ingredients
- Next: other countries' experiences

- **Income and Population:** Maddison Project (Bolt and van Zanden 2013), Broadberry et al (2010)
- **Urbanization:** Bairoch (1988), World Bank (2015)
- **Fertility and Mortality:** Wrigley and Schofield (1983), Clark (2009), Mitchell (1998), Gapminder (2009)

Back

Proof of Value Function Equalization

Equilibrium conditions expressed in terms of n, g, and prices:

- Recall budget constraint:

$$c + \frac{w_j(h' - h)n}{\xi} + \frac{w_j hn}{\alpha S_j} = w_j h \tag{27}$$

- Use $c = \tau_c w_j h$ to get normalized budget constraint:

$$\tau_c + \frac{gn}{\xi} + \frac{n}{\alpha S_j} = 1 \tag{28}$$

- And Euler equation:

$$(1+g)^{1-\sigma} = (\frac{n'_k}{n})^{\phi\sigma+1}(\frac{w'_k}{w_j})^{\sigma}\beta(\frac{\xi\tau_c}{n'_k} + g'_k) \tag{29}$$

- Implication: Dynasty's choice of n_t and g_t depend only on locations, $w_{t,j}$'s, and $S_{t,j}$'s
- Dynastic utility in sequence form is:

$$V_0 = \sum_{t=0}^{\infty} \beta^t \frac{(c_t n_t^{\phi})^{\sigma}}{\sigma} \tag{30}$$

- $\mathcal{J}(t)$ is the sector chosen in period t. Equilibrium utility becomes:

$$V_0 = \sum_{t=0}^{\infty} \beta^t \frac{(\tau_c w_{t,\mathcal{J}(t)} h_t n_t^{\phi})^{\sigma}}{\sigma} \tag{31}$$

- Divide by h_0^σ:

$$V_0 = h_0^\sigma \sum_{t=0}^{\infty} \beta^t \frac{(\tau_c w_{t,\mathcal{J}(t)} \frac{h_t}{h_0} n_t^\phi)^\sigma}{\sigma} \tag{32}$$

- Normalized human capital is:

$$\frac{h_t}{h_0} = \prod_{s=0}^{t-1} (1 + g_s) \tag{33}$$

- Given optimal sequence of g_t, n_t, and given sequence of wages, then the utility for a given location sequence $\mathcal{J}$ is the function:

$$V_{\mathcal{J}}(h) \propto h^\sigma \tag{34}$$

- Consider two different location sequences $\mathcal{J}$ and $\mathcal{J}'$
- If a household is indifferent for some $\hat{h}$, then

$$V_{\mathcal{J}}(h) = V_{\mathcal{J}'}(h) \quad \forall h > 0 \tag{35}$$

- If a household strictly prefers $\mathcal{J}$ for some $\hat{h}$, then

$$V_{\mathcal{J}}(h) > V_{\mathcal{J}'}(h) \quad \forall h > 0 \tag{36}$$

- For location equilibrium, households must be indifferent between urban and rural locations for some $\hat{h}$.
- Let $\mathcal{J}_U$ and $\mathcal{J}_R$ denote their optimal location sequences given a current choice of urban or rural. Then:

$$V_{\mathcal{J}_U}(h) = V_{\mathcal{J}_R}(h) \quad \forall h > 0 \tag{37}$$

- Because $\mathcal{J}_R$ is optimal for $\hat{h}$, there is no other sequence $\mathcal{J}'$ such that

$$V_{\mathcal{J}'}(h) > V_{\mathcal{J}_R}(h) \quad \exists h > 0 \tag{38}$$

- Sequence indifference implies that for any $\mathcal{J} \in \{\mathcal{J}_U, \mathcal{J}_R\}$

$$V(h) = h^\sigma \sum_{t=0}^{\infty} \beta^t \frac{(\tau_c w_{t,\mathcal{J}(t)} \prod_{s=0}^{t-1}(1+g_s) n_t^\phi)^\sigma}{\sigma} \tag{39}$$

$$\equiv h^\sigma \mathcal{V} \tag{40}$$

- Marginal values equalized:

$$V'(h) = \sigma h^{\sigma-1}\mathcal{V} = V'_{\mathcal{J}}(h) \quad \forall \mathcal{J} \in \{\mathcal{J}_U, \mathcal{J}_R\} \tag{41}$$

- $\sigma < 1$ so $V(h)$ is concave

Back