Population, Human Capital, and Economic Growth

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Abstract

This study constructs a dual economy consisting of agricultural production in the rural and manufacturing in the urban. In addition to quantity-quality trade-off of children, this study considers the interaction between housing price and quantity of children. With perfect rural-urban mobility, this model reproduces the demographic and economic-growth transitions from malthusian to post-malthusian and, then, to modern regimes.

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1. Introduction

It is believed that industrial revolution changed the way people live in several respects. First and foremost, prior to 200 years ago, the population grew at steady but significantly low rates. Then, all of a sudden, population grew at slightly above population reproduction rates in those economies with more advanced technologies.

The transitions of living standard in terms of income per capita are equally fascinating. Living standard was stagnant throughout the history excluding temporary fluctuations from natural disasters and wars. According to Clark (2005), construction workers living in England earned roughly the same real day wages between 1200 A.D. and 1850 A.D. Since then, income per capita had boosted (Figure 1).

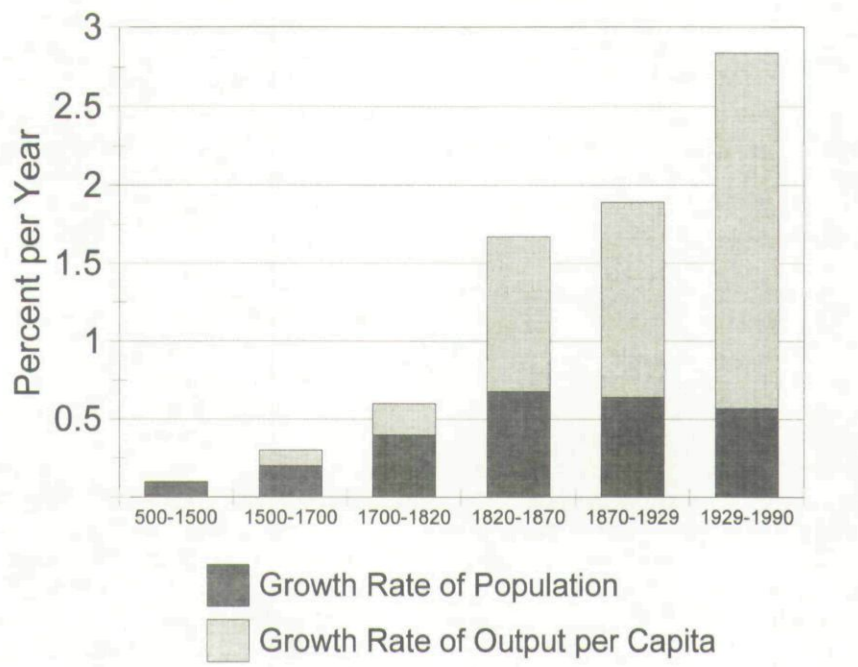

Figure 1. Output Growth in Western European, A.D. 5 0 0 ~ 1 9 9 0

Source: Galor and Weil (2000). Dala from 500-1820 are from Angus Maddison (1982) and apply to Europe as a whole. Data for 1820-1990 are from Maddison (1995), Table G, and apply to Western Europe.

Along the transitions of population and living standard, three regimes can be distinguished in chronological order - malthusian regime, post-malthusian regime, and modern regime. In the malthusian regime, both income per capita and fertility grew at low rates. In the post-malthusian regime, income per capita grew faster than population did. In the modern regime, income per capita grows fastest while fertility rate remains low.

The phenomenon of population and living standard interactions happened in the malthusian regime could be explained well by Thomas Robert Malthus in his famous writing - An Essay on the Principle of Population (1798). He postulated that, because of limited resources and fairly slow technological progress, any increment in income per capita would be eliminated by raising population. Living standard remained constantly low.

Modern economic growth theories, which proposed by Solow, Ramsey, Diamond, Lucas, and Romer to name a few, are quite handy in describing the trajectories of income per capita after industrial revolution. Incorporating the children's quality and quantity trade-off theory (Becker and Lewis, 1974), modern economic growth theories suggest that fertility reduces when income per capita speeds up in the modern regime. Therefore, it is in our expectations that an increase in income per capita accompanying with a lowered fertility rate observed in the modern regime.

Since Malthus population theory can only be applied to malthusian regime while modern economic growth theories can only be applied to modern regime, several studies attempt to solve the puzzle of shifting regimes. i.e. unified economic growth theories. Galor and Weil (2000) and Galor and Moav (2002)[2] hypothesizes that technological progress increases education returns and induces education investment from the parents, therefore, reduces the fertility. Clark and Cumins (2009) points out that in order for this theory to work there must exist the subsistence consumption minimum, and that when income per capita slightly higher than this minimum fertility is positively related to the income per capita. However, when living standard is much higher than this minimum, fertility is negatively related to it. According to Clark and Cumins' finding, this is contrary to England's historical data in the malthusian regime.[3]

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[2] Building upon Barro and Lewis(1989) and Becker, Murphy, and Tamura(1990).

[3] Later on, this study will adress this issue.

In another attempt, Hansen and Prescott (2002) postulates that technological advancement finally turns manufacturing productions profitable and shifts resources away from agricultural productions. This theory succeeds in reproducing transitions in all three regimes. The drawback is that for this theory to hold the preferences toward children must evolve from one regime to another.

Zhang (2002) takes the urbanisation approach. People live in the urban area earn more and, hence, the cost of education investment for the parents is higher compared to rural area. With better formal education in urban area assumption, parents in urban area tend to raise less but higher quality (in terms of education) children. With urbanisation, people move from rural area to urban area. Therefore, fertility rate reduces over time while income per capita increases. Obviously, this theory can only be applied to the transition from post-malthusian to modern regimes.

This study follows the line of urbanisation in explaining transitions from one regime to another with a little twist. In the original Becker and Lewis (1974)'s quantity-quality trade-off theory, children are viewed as parents' consumption. As parents trying to maintaing this consumption, quantity of children must be sacrificed when parents decide to have higher quality children. In addition to children, housing is an important share of parental consumption. When housing spaces affect the family sizes, housing prices influence fertility. Simon and Tamura (2009) reveals a negative relationship between housing prices and number of children in U.S. households during 1940 and 2000[4]. Therefore, housing prices do impact fertility decisions. Rural area has lower population density and lower housing price while urban area has higher density and higher housing price. Hence, rural parents choose to raise more children than urban parents do given same quality of children.

It is this wedge between rural and urban housing prices that post-malthusian regime transits to modern regime. In the malthusian regime, population density and, hence, housing price were low. Low income per capita prevented parents from rearing more surviving children. The economy was almost stagnant. Up to certain point, manufacturing production became profitable because of human capital accumulation. Urbanisation proceeded and inhabi-

[4] Other works are Browning and Ejrnaes(2009) and Michelini(2001) among others.

tants gradually moved from rural to urban area. Post-malthusian regime began. Because density in the urban area was low, urban housing price remained low. Parents chose to have more children when they earned more. The economy grew with larger urban share of population. In the modern regime, with increasing population, urban density pushes up housing price and parents invest in education but rear fewer children. Income per capita growth rate outpaces population growth rate.

2. The Model

A. Production Technology

Since the purpose of this study is to explore the possibility of reproduction of transitions of three different regimes in the context of urbanisation, a dual economy consisting of manufacturing and agricultural productions is constructed. In this model economy, agricultural production exists only in the rural area while manufacturing exists only in the urban area. This assumption represents the historical facts that the majority of population resided in the rural area and produced mostly agricultural goods before industrial revolution (i.e. the Malthus sector) and that the main economic activities are manufacturing in the urban area (i.e. the Solow sector) in the modern days. The agricultural production takes human capital, physical capital, and land as inputs.

$$(1) \quad Y_r = A_r K_r^{\varphi} H_r^{\mu} X_r^{(1-\varphi-\mu)}$$

and competitive firms solve the following problem:

$$(2) \quad \pi_r = A_r K_r^{\varphi} H_r^{\mu} X_r^{(1-\varphi-\mu)} - v_r K_r - \omega_r H_r - r_L X_r$$

where subscript r denotes rural area, A_r total factor productivity of agriculture, K_r total physical capital used in agricultural production, H_r total human capital used in agricultural production, and X total land available for agricultural production. Agricultural land is in fixed supply and is normalized to 1. The physical capital rental rate (v_r) and the wage rate (w_r) under the assumption of competitive market are

(3) $\omega_r = \mu A_r K_r^{\varphi} H_r^{\mu-1} X_r^{(1-\varphi-\mu)}$

(4) $v_r = \varphi A_r K_r^{\varphi-1} H_r^{\mu} X_r^{(1-\varphi-\mu)}$

The manufacturing production takes human capital and physical capital as inputs.

(5) $Y_u = A_u K_u^{\Delta} H_u^{1-\Delta}$

and competitive firms solve the following problem:

(6) $\pi_u = A_u K_u^{\Delta} H_u^{1-\Delta} - v_u K_u - \omega_u H_u$

where subscript u denotes urban area, A_u total factor productivity of manufacturing, K_u total physical capital used in the manufacturing production, H_u total human capital used in manufacturing production. The competitive physical capital (v_u) and the wage rate (w_u) are

(7) $\omega_u = (1-\Delta) A_u K_u^{\Delta} H_u^{-\Delta}$

(8) $v_u = \Delta A_u K_u^{\Delta-1} H_u^{1-\Delta}$

Corresponding to the family farm, agricultural production is relatively land-intensive. Manufacturing production, on the other hand, is relatively capital-intensive and is corresponding to the modern factory. With this assumption underlying these production functions, Δ is assumed to be larger than φ. Land, a fixed factor in this model, does not enter manufacturing production at all. Output from either agricultural or manufacturing productions can be used for consumption or investment. Physical capital is assumed to depreciate fully at the end of each period for simplicity.

B. Preferences

In the model economy, there is an infinite number of identical agents who live for three periods - young children, middle-aged parents, and retired old. To mimic actual household behaviours, middle-aged parents make the decisions about how much to consume right away, how much to save for the old days, the number of children, the education investment per child, and the size of the houses. Hence, the lifetime utility of a parent in time t is

(9) $U_t = \alpha_1 \ln C_1 + \alpha_5 \ln C_2 + \alpha_2 \ln n + \alpha_3 \ln d + \alpha_4 \ln e$

where $c_{1,t}$ denotes the consumption in time t, $c_{2,t+1}$ the consumption in time t+1 or retired, n_t the number of children, d_t housing space, and e_t the education level of children.

Each middle-aged agent is endowed with one unit of labor and earns wage income. Wage income is used to finance consumption, children, housing, and future consumption. The lifetime budget constraint of a parent is

(10) $wh(1-\delta n) = C_1 + C_2/(1+v) + r\varepsilon n + rdn + ne$

where δ denotes the fixed unit of labor time a parent has to forgo in order to rear a child, r the housing price per unit of space, and ε the minimum requirement of housing space per child.

As mentioned above, this study follows Becker and Lewis (1974) and views children as the consumption of their parents. Furthermore, this study considers housing consumption. The total housing space for each child is ε plus d. This setting is used to make sure parents won't choose un-tolerable small housing space for each child. This also suggests that there exists some complementary relationship between consumptions of housing and number of children.

A parent's problem is to maximise his utility subject to his budget constraint. Lagrangian is writing as

(11) $$\begin{aligned}\mathcal{L} &= \alpha_1 \ln C_1 + \alpha_5 \ln C_2 + \alpha_2 \ln n + \alpha_3 \ln d + \alpha_4 \ln e \\ &\quad + \lambda[I(1-\delta n) - C_1 - C_2/(1+v) - r\varepsilon n - rdn - ne]\end{aligned}$$

F.O.C.s for the household's optimisation problem yield the following expressions:

(12) $C_1 = (\alpha_1/(\alpha_1+\alpha_2+\alpha_5))wh$

(13) $S = C_2/(1+v) = \left[\alpha_5/(\alpha_1+\alpha_5+\alpha_2)\right]wh$

(14) $n = \left[(\alpha_2-\alpha_3-\alpha_4)/(\alpha_1+\alpha_5+\alpha_2)\right]\left[(wh)/(\delta wh + r\varepsilon)\right]$

(15) $e = \alpha_4(\delta wh + r\varepsilon)/(\alpha_2-\alpha_3-\alpha_4)$

(16) $d = \alpha_3(\delta wh + r\varepsilon)/(\alpha_2-\alpha_3-\alpha_4)r$

Noting that housing price enters some decisions, an increment in the housing price reduces both housing space per child and the number of children but induces education investment. Also noting that fertility depends upon wage income, a raise in the wage payment leads to greater number of children and education. Corresponding to Clark and Cumins (2009), these two features set apart this study from others.

The human capital accumulation behaves

(17) $h_t = \psi e_{t-1}^{\tau}\bar{h}_{t-1}^{1-\tau}$

where ψ denotes human capital productivity and $\bar{h}$ the average human capital level of parent's generation. This specification allows knowledge spillover between rural and urban areas without limitations.

C. Competitive Equilibrium

Inter-regional migration is allowed in both directions. At the beginning of the second period, middle-age, agents can choose whether to migrate to the other area without limitations. However, an urban agent won't consider migration as the mean to improve his lifetime utility. Since an urban agent equips with higher human capital and urban wage is higher, his lifetime utility without migration to rural area is always higher than the one with migration. Agents flow from rural to urban areas only. The no migration condition holds when an agent's lifetime utility with migration to urban area equals to his lifetime utility without migration. In terms of indirect utility, the condition follows

$$(18)\quad \begin{aligned}&(\alpha_1+\alpha_5+\alpha_2)\ln\omega_r h_r-(\alpha_2-\alpha_3-\alpha_4)\ln(\delta\omega_r h_r+r_r\varepsilon)-\alpha_3\ln r_r\\&=(\alpha_1+\alpha_5+\alpha_2)\ln\omega_u h_r-(\alpha_2-\alpha_3-\alpha_4)\ln(\delta\omega_u h_r+r_u\varepsilon)-\alpha_3\ln r_u\end{aligned}$$

Population evolves in urban and rural areas in the following forms.

$$(19)\quad L_{ut}=n_{ut-1}L_{ut-1}+n_{mt-1}L_{mt-1}$$

$$(20)\quad L_{rt}=n_{rt-1}L_{rt-1}-L_{mt}$$

Let L_{ut} denote the amount of labor who was born in the urban area and devotes to manufacturing production at time t, L_{rt} the amount of labor who was born in the rural area and devotes to agricultural production at time t, and L_{mt} the amount of labor who migrates from rural to urban at time t.

Therefore, the amount of physical capital in urban area at time t, K_{ut}, is

$$(21)\quad K_{ut}=S_{ut-1}L_{ut-1}+S_{mt-1}L_{mt-1}$$

and the amount of physical capital in rural area at time t, K_{rt}, is

$$(22)\quad K_{rt}=S_{rt}L_{rt-1}$$

Total human capital is the aggregation of human capital in that area. Each middle-aged agent who lives in urban area has the amount of human capital at time t, h_{ut}, and each one who lives in rural area has the amount of human capital at time t, h_{rt}. Since the migration decisions are made at the beginning of the middle-aged period and the education is taken when young, migrants are equipped with h_{rt} of human capital at time t. Total human capital in urban area is written as

$$(23)\quad H_{ut}=h_{ut}L_{ut}+h_{rt}L_{mt}$$

and total human capital in rural area is

$$(24)\quad H_{rt}=h_{rt}L_{rt}$$

Given initial conditions of population, physical capital, and housing price series for both areas over time, equations (3), (4), (7), (8), (12)-(16),and (17)-(24) define an equilibrium sequence of prices and quantities,

$$\{w_{ut}, w_{rt}, v_{ut}, v_{rt}, h_{ut}, h_{rt}\}$$

3. Quantitative analysis and Conclusion

In this section, this study fits the model with U.K. data to mimic the observed values of the variables during and after industrial revolution. In the model, each period is 20 years and, hence, life span is 60 years. Individual preference parameters, α_1, α_2, α_3, α_4, and α_5, are 1, 1.26444, 0.247564, 0.162716, and 0.4475, respectively. Technology parameters, A_r, A_u, φ, μ, and Δ, are 10.7282, 16.8091, 0.1, 0.6, and 0.4, respectively. The fraction of time used in rearing each child, δ, is set at 0.1125. ε here is 6.74268. Education parameters, Ψ and τ, are 1.6806 and 0.2.

In the first period, $t=t_0$, there is no migration. The model is calibrated to permit the economy to rely on the rural agricultural production solely in that period. The initial human capital of a rural capital worker is normalised to 1.

The numerical solution can be found by repeating the following steps.

1. Given n_{ut-1}, n_{rt-1}, L_{ut-1}, L_{rt-1}, K_{ut}, K_{rt}, h_{ut}, h_{rt} and housing prices r_{ut} and r_{rt}, equation (18) determines L_{ut}, L_{rt}, L_{mt}, w_{ut}, w_{rt}, v_{ut}, and v_{rt}.
2. Given w_{ut} and w_{rt}, equations (14), (15), (16), and (17) solve for n_{ut}, n_{rt}, e_{ut}, e_{rt}.
3. Given e_{ut} and e_{rt},equation (17) determines h_{ut+1} and h_{rt+1}.
4. Given w_{ut} and w_{rt}, equations (13), (21), and (22) determine K_{ut+1} and K_{rt+1}.

The model is simulated for 20 periods, and preliminarily results show that fertility rates for both urban and rural families are 2.26 and 5 in the modern regime. These rates are close to observed data reported in other researches. After 20 periods of simulation, urban population is almost accounted for 80 % of total population.

Table 1 - Parameter Values

Parameter	Definition	Value	Comments
α	Consumer preference	1	Base line
α	Consumer preference	1.26444	Matching housing data
α	Consumer preference	0.247564	Matching housing data
α	Consumer preference	0.162716	Matching 6% of GDP
α	Consumer preference	0.4475	Following De la Croix
ε	Min. requirement of housing space	6.74268	Matching housing data
δ	Opp. cost of raising children	0.1125	Matching data of rearing children
ψ	Human capital productivity	1.6806	Matching 2% annual economic growth rate
τ	Elasticity of human capital with respect to educational investment	0.2	Following Chen
φ	Capital share in agricultural production	0.1	Following Hansen and Prescott (2002)
μ	Human capital share in agricultural production	0.6	Following Hansen and Prescott (2002)
Δ	Capital share in manufacturing production	0.4	Following Hansen and Prescott (2002)
A	Manufacturing total factor productivity	16.8091	Consistent with annual 2% economic growth rate
A	Agricultural total factor productivity	10.7282	Consistent with population growth in malthusian regime that population doubled every 230 years

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