Does Malthus Really Explain the Constancy of Living Standards?

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Abstract

Conventional wisdom holds that Malthusian theory explains the constancy of living standards before the industrial revolution: population grows faster when living standards rise; changes in technology alter the density of population but not the average welfare. This paper challenges the Malthusian explanation of the constancy and replaces it with the idea of group selection.

Malthusian theory is inadequate because it misses the fact that a dollar's worth of diamonds contributes less to survival and reproduction than a dollar's worth of grain. Grain is a subsistence commodity and a diamond is a surplus one. The Malthusian force anchors the average level of subsistence, but not that of surplus. If the surplus sector had grown faster than the subsistence sector, the living standards could have grown steadily before the industrial revolution. The Malthusian fact of constancy of living standards thus implies a balanced growth between surplus and subsistence, something Malthus did not explain.

I propose the theory of group selection to explain the balance of growth. Selection of group characters, including culture and technology, takes place by migration and war. Since living standards rise with the relative productivity of surplus, migrants and invaders are attracted from places relatively rich in subsistence to those relatively rich in surplus. They spread the culture and technology of their subsistence-rich hometown to the surplus-rich destination - the bias of migration favors the spread of subsistence over that of surplus. Even if surplus cultures and technologies develop faster than subsistence in a local environment, the offsetting force of the biased migration balances the two sectors on a global scale. This explains the constancy of living standards.

This new theory reinterprets the Malthusian constancy, the industrial revolution and the ancient market economies.

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1 Introduction

> All other arguments are of slight and subordinate consideration in comparison of this. I see no way by which man can escape from the weight of this law which pervades all animated nature.
>
> Thomas Malthus, 1798

> But in economics, the admission that mankind need not live at the margin of subsistence ... meant that, the very long run limit of wages was not physiological subsistence, it was *psychological subsistence* - a much more complicated and difficult matter to formulate exactly.
>
> Lionel Robbins

Life is miserable for most who lived before 1800. There is little to spare after the need for subsistence is met. The want of surplus lasts and prevails. "The average person in the world of 1800 was no better off than the average person of 100,000 BC" (Gregory Clark, 2007). Material lifestyle varies from place to place, but by the modern standard, the variation is small and shows no sign of correlation with the sophistication of technology (Clark, 2005, Ashraf and Galor, 2011).

Understanding the persistent poverty almost became a hindsight. On the eve of the industrial revolution, in the year of 1798, Thomas Malthus published *An Essay on the Principle of Population*, a book of one single idea that forever changed the world's view on the fate of humanity. In Malthus's view, men are trapped in vice and misery because progress only brings about faster population growth. The larger population depresses wages and brings about poverty. Poverty causes contraception and prostitution, and breeds famine and disease. In vice and misery, the living standards are held in check, since population could potentially grow faster than the economy.

Today the Malthusian insight remains basic to every economist's understanding of human history. Few, if any, doubt Malthus's explanation for the phenomenon named after him - the Malthusian constancy of living standards. This paper breaks the norm by showing that the familiar Malthusian theory is a secondary explanation. The primary answer turns out to lie in another idea that was also historically inspired by Malthus, the idea of selection.[1]

[1] During a casual reading of Malthus on Population, Charles Darwin suddenly realized that"under the circumstances [of the struggle for existence], favorable variations tend to be preserved, and unfavorable ones to be destroyed." While Malthus closely watched the race between the aggregate variables - the population and the resource, Darwin paid attention to the composition of population and the selection that occurs within. Ironically, with inspiration from Malthus, Darwin stumbled on the solution to the mystery Malthus had meant to explain.

Explaining the constancy lies in the core of Malthusianism. Attacking the periphery would pose no serious challenge to Malthusian theory. Critics have long noticed the weak correlation between real wage and population growth rate in premodern England. But the weakness never undermines economists' belief in the long-term relevance of Malthusian theory. Most believe that "no matter how weak, this tug [of the Malthusian force], by its systematic persistence, comes to dominate human population dynamics over the long run, if not the short (Clark, 2008)."

But the success of predicting the long-run constancy is an illusion. The prediction is right but the mechanism is wrong, analogous to a detective figuring out the true murderer by a false reconstruction of the scene of the crime. The judge should not be satisfied with a mere lucky guess.

I reject Malthus's explanation for the constancy of living standards and provide a new theory to replace it. Constancy arises because of a biased selection of culture and technology. It favors group prosperity at the expense of individual welfare. Hence I call it the theory of "group selection".

Malthusian theory is inadequate because it misses the fact that a dollar's worth of grain contributes more to survival and reproduction than a dollar's worth of diamonds. Grain is a subsistence commodity and diamonds a surplus one.

For any two different commodities, we can identify one as a subsistence relative to the other as a surplus. Calculate the marginal effects of each commodity, in per capita terms, on the growth rate of population and on an average person's utility. For each commodity, define a "subsistence index" as the ratio of the marginal growth rate to the marginal utility. Subsistence index measures the commodity's demographic effect relative to its hedonistic value.

Grain has a higher subsistence index than diamonds, hence grain is a relative subsistence. In the same way, agricultural products are a subsistence relative to manufacture products; arables relative to pastures; and barley and oats relative to wheat. We can order all the commodities by their subsistence index and divide the whole spectrum into two groups. One forms the surplus sector and the other the subsistence sector. My theory thus differs from the Malthusian model by having two sectors instead of one.

Changes of productivity in different sectors affect population growth differently. The use of a more effective fertilizer feeds more people; but a better diamond cut does not. Progress in surplus technology has little effect on population growth, hence the Malthusian force cannot hinder the growth of average surplus.

Living standards depend on both average surplus and average subsistence. Since average subsistence has been fixed by the Malthusian force, average surplus solely determines the equilibrium living standards. Average surplus is equal to the relative productivity of surplus multiplied by average subsistence:

$$\frac{\text{Surplus}}{\text{\# of Men}} = \frac{\text{Surplus}}{\text{Subsistence}} \times \frac{\text{Subsistence}}{\text{\# of Men}}.$$

Now that average subsistence is fixed, the living standards depend on the relative productivity of surplus only. The relative productivity varies from place to place. The higher it is, the greater the living standards.

In the long run, living standards could have grown steadily. It would have happened as long as surplus had grown faster than subsistence; and the Malthusian force would have had no way to check it. The relative growth of surplus would even create a momentum for itself: the higher the living standards, the greater the demand for surplus - surplus is a luxury and its demand rises with income - and the rise in surplus consumption would further increase the living standards. But nothing of this sort ever happened before the industrial revolution. The lack of growth implies that surplus had grown at the same rate as subsistence. The puzzle of Malthusian constancy is essentially a puzzle of balanced growth.

I proposed several explanations for the puzzle of balanced growth. The hypothesis of group selection is the most convincing of all.

Group selection takes place in the spread of subsistence technologies. We call one a subsistence technology if that technology raises subsistence productivity more than surplus productivity. Examples include potato, maize and fertilizers. A subsistence technology decreases the relative productivity of surplus. It causes the equilibrium living standards to decline and drive the people who adopt it to migrate abroad for a higher living standard. As a result, subsistence technologies spread faster than surplus technologies.

How could a technology get spread faster by making people worse off? The paradox arises because individuals will not take into account the effect of their behavior on group welfare. An 18th-century Irish peasant would not refrain from cultivating potato by foreseeing the misery of a denser population. Even if he refrained, he could not stop the other peasants from tilling potato and bearing more children. Everyone seeks a better life; each pursues her own agenda; but collectively, they evoke “the tragedy of the commons”.

Contrariwise, the people who adopt the surplus technologies are reluctant to go to the “gentiles” to spread the “gospel.” So the technological spread by migration is asymmetric, favoring the spread of subsistence over that of surplus. The character of an idea, by changing the bearer’s behavior, decides the fate of its own dissemination.

People might have been innovating surplus faster than subsistence. If there had been no selection - either migration was forbidden or people moved randomly instead of seeking a better life - the relative productivity of surplus would have grown steadily, and so would the living standards. But selection offsets the local advantage of surplus growth by the global advantage of subsistence spread. Left alone, every place would have prospered; but globally, they were held in check by the interlock of selection. Selection picks the poverty-stricken and makes their lifestyle prevail.

The same logic extends from technology to culture. Culture is the social norm that sorts out winners and losers. The winners gain status, respect and the favor of the other sex. To be such a winner, people show off in galleries and theaters, in Fashion Weeks and Olympic Months. These surplus cultures divert resources from supporting a larger population to promoting one's social status. In other words, surplus promotes individual's fitness at the expense of group's fitness.

The demand for surplus is the individuals' Nash equilibrium strategy, commonly held and genetically programmed, that survives natural selection and makes us who we are. No art or music would be possible but for the demand of surplus; and none would demand surplus but for the conflict of interest between individual and group. By the measure of fitness, surplus consumption is a prisoner dilemma; yet by the measure of utility, it is a blessed curse.

Surplus culture makes people better off. It requires one to spend more on surplus and less on subsistence. As a result, population is lower than if the surplus culture is absent. In the long run, the average subsistence will change little but the average surplus will become greater. Altogether, surplus is "socially free": when people desire more, they get more in the end; and they do not have to pay for it by sacrificing average subsistence. The people who pay for the surplus are those who would have been born.

But surplus culture has a limit. The hedonism is checked by migration and invasion. The "arms race" of hedonism makes a people vulnerable to greedy neighbors: the high surplus attracts the invaders; and the low subsistence means fewer people to defend it. This is why the arms race of conspicuous consumption does not spiral out of control. Locally, it might escalate; globally, it is suppressed by group selection. I call the process group selection because culture is a group character. Culture affects the fate of the group; and by doing so, it decides its own fate. By suppressing surplus culture, group selection traces out a path of balanced growth. Along the path, mankind were trapped for tens of thousands of years in the constancy of living standards.

My theory has two parts. The two-sector model raises the puzzle of balanced growth; then the theory of group selection solves the puzzle. Together they answer Malthus's question: why living standards had stagnated for such a long time.

Implications of the theory go far beyond Malthus. Consider the ancient market economies, such as Roman empire and Song dynasty. The classical theory portrays their prosperity as an ephemeral carnival, a temporary "disequilibrium" of the Malthusian model. In contrast, my theory attributes the prosperity to the persistent effect of long peace, wise governance, light tax and market economy. These "Smithian" factors boost surplus productivity more than subsistence productivity. As a result, they improve equilibrium living standards not only in Solow's era but also in Malthus's time.

The theory also addresses the twin puzzles of the agriculture revolution - why living standards declined after men took up agriculture and why agriculture swept the world despite its negative effect on living standards. In light of my theory, agriculture is a subsistence technology. It lowers the equilibrium living standards and spreads fast by the help of group selection.

Last but not the least, the theory puts the industrial revolution into perspective. Explosive changes such as the appearance of agriculture, the rise of Islam, the march of Genghis Khan and the industrial revolution all share the same pattern: a surplus turns into a subsistence - a local trait attempts global dominance by winning over group selection from a constraint into a boost. These phenomena are called surplus explosions. Since surplus explosion is a law of evolutionary biology, it strengthens the thesis that human economic welfare, both when it stagnates and when it explodes, can be understood in an evolutionary biological framework.

Stories without evidence are merely a fable. I need to prove three things to establish the theory. First, I shall demonstrate the empirical distinction between surplus and subsistence. Second, I shall show the pattern of source-sink migration in history. Third, I shall present evidence that selection is strong enough to dominate counteractive forces. I prove the three parts in different ways: econometrics and biological analogy for the first, summary of data and narrative evidence for the second, and computer simulation and historical review for the third.

2 Literature review

How sound is the Malthusian constancy as a fact? Figure 1 and figure 2 show the evolution of English real wage and population between 1200 and 1800. While population in 1800 was twice as high as in 1200, there was little trend in the real wage.

The lack of trend is in fact universal. Figure 3 shows Maddison's estimate of the world's GDP per capita for the last two millennia. Using Maddison's data, Ashraf and Galor (2011) confirmed that by year 1500, the level of technology of a country explains the density of population, but not the income per capita.

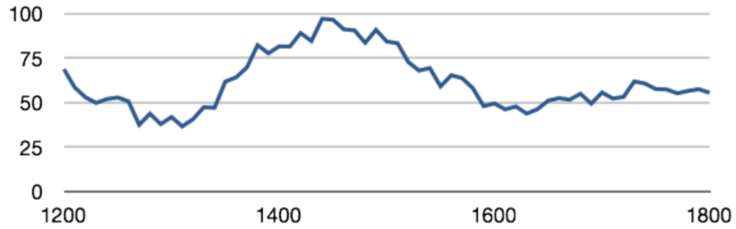

Figure 1: English real wage, 1200 - 1800 (1860=100)

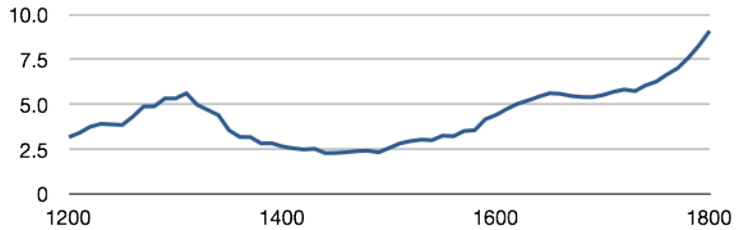

Figure 2: English population, 1200 - 1800 (million)

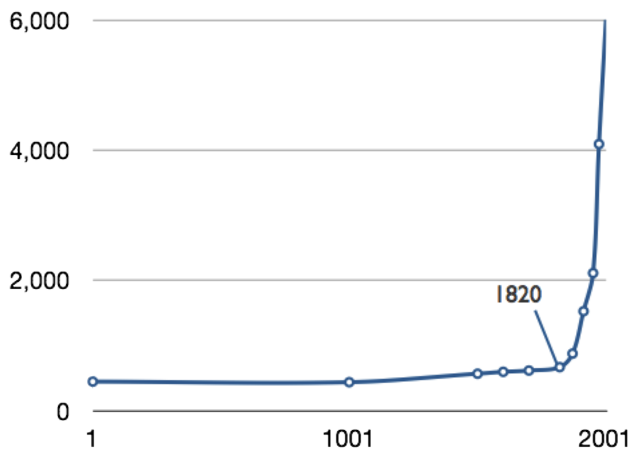

Figure 3: World per capita GDP 1-2001 AD, in 1990 dollars

Though the Malthusian fact is established, the Malthusian theory is no less controversial than in the times of Malthus. In 2007, Gregory Clark published *A Farewell to Alms*, which ignited a heated debate on Malthusianism. Clark says the history of mankind by 1800 can be explained by a single model, the model of Malthusian theory. Some of the other best talents in our profession quickly responded. Most of the critics - Wrigley[2], Allen (2008), De Vries[3], among many others - point to the empirical weakness of the Malthusian theory. They cited the empirical work of Ronald Lee and his colleagues[4] who found that wage and population growth are poorly correlated in the English data. As Jan de Vries put it, "The Malthusian force is rather weak, that is, shifts of birth rate and death rate schedules are more important than movements along the schedules." Figure 4 illustrates the point by plotting the rates of birth and death against the real wage[5].

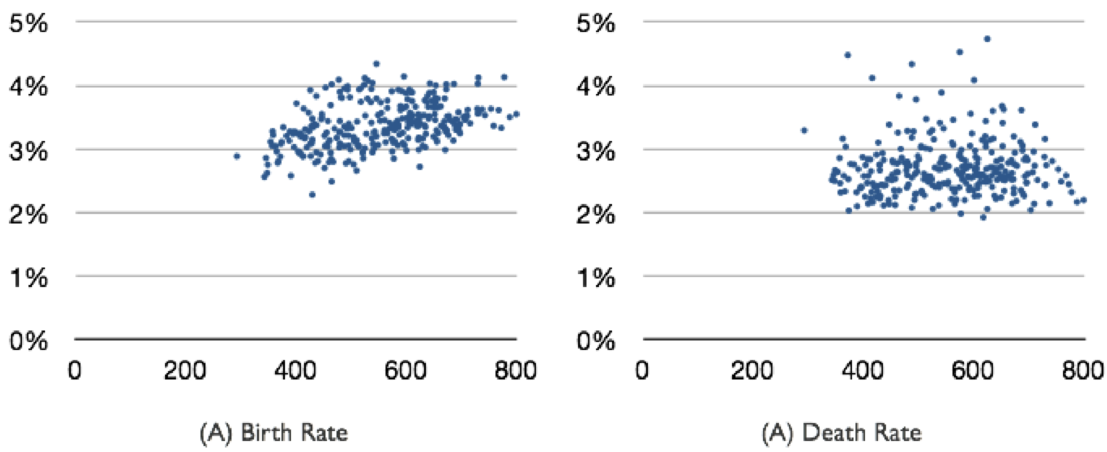

Figure 4: Real wage explains the birth and death rates weakly.

Yet despite the weakness, most scholars still believe the Malthusian force to be the cause of the long-run constancy. In their view, while it takes centuries for an economy to move back to equilibrium, the Malthusian force dominates in the long run by its persistent tug. Allen (2008) was upset about the conjecture but did not mention any alternative explanation.

Besides the empirical attack, Malthusianism receives no less challenge to the theory. The critics are concerned with Malthus's failure to capture the modern growth. Scholars in the 19th century[6] had noticed the potential of technological

[2]E. A. Wrigley, book review, Population and Development Review, Dec 2008

[3]Jan de Vries, book review, Journal of Economic History, Dec 2008

[4]Lee 1980, 1987 and Lee and Anderson 2002

[5]The plots are for the period 1539 - 1836. The horizontal axis is the real wage index compiled by Wrigley and Scholfield (1989).

[6]Malthus (5th ed., 1817/1963), Everett (1826), Carey (1840) and Engels.

improvement to outpace the population growth. They saw the possibility of "moral restraint", that people might refrain from reproduction voluntarily.

Today's theorists have a different agenda. They attempt to reconcile the Malthusian constancy with modern growth by endogenizing the acceleration of productivity growth.[7] These models unanimously presumed the Malthusian mechanism to be the cause of Malthusian constancy. They described how the shackle of Malthusian forces was finally broken; but they never asked whether the binding shackle was truly Malthusian or not.

I propose this question. The question is inevitable in a two-sector Malthusian model. Rudimentary two-sector models did occasionally appear. Davies's (1994) paper on Giffen goods had beef and potato. Taylor's (1998) classic on Easter island had food and manufactures. Two-sector thinking also permeated empirical studies such as Broadberry and Gupta (2005), which used the ratio of silver-grain wages to proxy for the relative productivity of tradable goods. Unfortunately, the researchers never took a further step to explore the long-run implication, that a directional change in production structure could disturb the constancy of living standards.

This paper explores the long-run implications. It turns out I have to face a new puzzle, the puzzle of balanced growth, which I explain with the theory of group selection. In the past decade, Bowles and Gintis[8] revived the idea of group selection in economic literature, asking why the cooperative traits got rooted in human nature, though they seem to conflict with individual fitness. The old label of pseudo-science on group selection is gone. Now there are many ways for group selection to have an impact. As in my theory, group selection takes place across the multiple equilibria, so it is compatible with Nash criterion.

Levine and Modica (2011) is the closest research to mine. They use the idea of group selection to challenge the Malthusian prediction of persistent poverty. Though we share the same solution to Malthusian economics, we approach the issue in different ways and reach different conclusions. They treat the constancy not as a solid fact to explain but as a false prediction to challenge. They do not distinguish surplus and subsistence, but instead focus on the allocation of resources between people and authority. Their equilibrium is the maximization of resources the authority controls to engage in wars; while mine is the balance of growth and constancy of living standards. My thesis is complementary to theirs. Together we show how the idea of group selection can change our view on the part of history which economists used to think is explained by a single model of Malthusian theory.

[7] Simon and Steinmann (1991), Jones (2001), Hansen and Prescott (2002), Galor and Weil (2002) and Galor and Moav (2002), among many others.

[8] Bowles and Gintis (2002) and Bowles (2006). Their work is summarized in the new book, *A Cooperative Species: Human Reciprocity and Its Evolution* (Bowles and Gintis 2011).

3 Models

3.1 The mathematical definition of surplus

Surplus is what contributes little to population, relative to its contribution to utility.

Suppose an isolated group of homogeneous people. The level of population is H. There are M kinds of commodities, $j = 1, 2, ..., M$. The representative agent's consumption is $E \in \mathbb{R}_+^M$. Within the choice set, he maximizes a utility function that is differentiable and strictly increasing:

$$\max_{E \in C(N)} U(E)$$

The choice set C shrinks when population rises: $\forall H_1 < H_2$, $C(H_1) \supset C(H_2)$.

Let the growth rate of population depend on the average consumption E,

$$\frac{\dot{H}}{H} = n(E)$$

Now assume the population growth rate $n(E)$ is differentiable and strictly increasing. There exist a set S on which population does not change, $n(S) = 0$. Call it the constant population set. When population stabilizes, an economy returns to its equilibrium on the constant population set.

When $U(E)$ is not a transformation of $n(E)$, there must exist some bundle of consumption E, at which one good is more of a subsistence than another, i.e., $\exists j_1, j_2 \in \{1, 2, ..., M\}$ such that

$$\frac{\frac{\partial n(E)}{\partial E_{j_1}}}{\frac{\partial U(E)}{\partial E_{j_1}}} > \frac{\frac{\partial n(E)}{\partial E_{j_2}}}{\frac{\partial U(E)}{\partial E_{j_2}}}$$

Compared with j_2, commodity j_1 marginally contributes more to population growth than to individual utility. It makes j_1 a subsistence relative to j_2. In fact, we can define a subsistence index for each commodity. $\forall E \in \mathbb{R}_+^M$, $\forall j \leq M$, commodity j's subsistence index at E is

$$\frac{\frac{\partial n(E)}{\partial E_j}}{\frac{\partial U(E)}{\partial E_j}}$$

Order the indices of all commodities from small to large. Then we get a spectrum of commodities from surplus to subsistence. I then divide the spectrum into two groups, the surplus sector and the subsistence sector.

The bottom line is, we can always distinguish surplus and subsistence as long as $U(E)$ is not a transformation of $n(E)$. Later I shall discuss why the condition is important.

3.2 The two-sector Malthusian model

Figure 5 illustrates the above algebra. It features the representative agent's consumption space. In addition to the conventional indifference curve and production possibility frontier, the diagram has a "constant population curve" (figure 5B): population stays constant if consumption bundle is on the curve. If consumption lies to the left of the curve - what people consume is not enough for reproduction - population declines; if to the right, population rises.

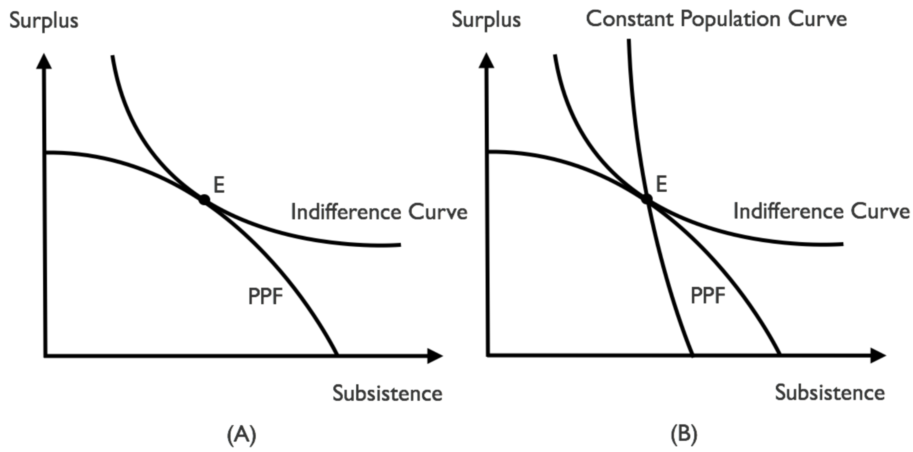

Figure 5: Adding the constant population curve

The change of population is reflected in the shift of production possibility frontier: when population declines, the frontier expands, for each person is endowed with a larger choice set; when population rises, the frontier contracts. Without loss of generality, I assume the expansion and contraction of the production possibility frontier to be proportional between the sectors. In other words, the production structure is neutral to the size of population.

The constant population curve crosses the indifference curve from above because subsistence is more important to population growth than surplus[9].

The equilibrium must lie on the constant population curve. As figure 6 illustrates, if the economy deviates rightward, the temporary affluence raises the growth rate of population. As population grows, individuals' choice set contracts, until the economy returns to the constant population curve.

[9]The direction of crossing follows the definition of surplus and subsistence: if we label subsistence as A and surplus as B,

$$\frac{\frac{\partial n(E)}{\partial E_A}}{\frac{\partial U(E)}{\partial E_A}} > \frac{\frac{\partial n(E)}{\partial E_B}}{\frac{\partial U(E)}{\partial E_B}} \Longrightarrow \frac{\frac{\partial n(E)}{\partial E_A}}{\frac{\partial n(E)}{\partial E_B}} > \frac{\frac{\partial U(E)}{\partial E_A}}{\frac{\partial U(E)}{\partial E_B}} \quad \text{i.e., } MRS_n > MRS_U$$

so the constant population curve is steeper than the indifference curve.

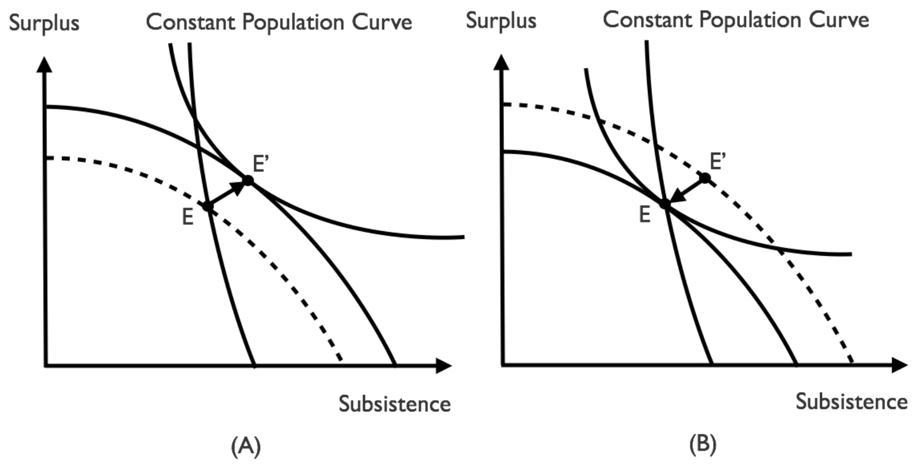

Figure 6: The equilibrium is on the constant population curve.

Now a surplus technology can improve the equilibrium living standards. The surplus technology expands the production possibility frontier vertically (figure 7A). After population adjustment, the economy returns to the constant population curve in the end (figure 7B). The new equilibrium (E'') is above the old one (E) because the production possibility frontier becomes steeper after the surplus technology shock.

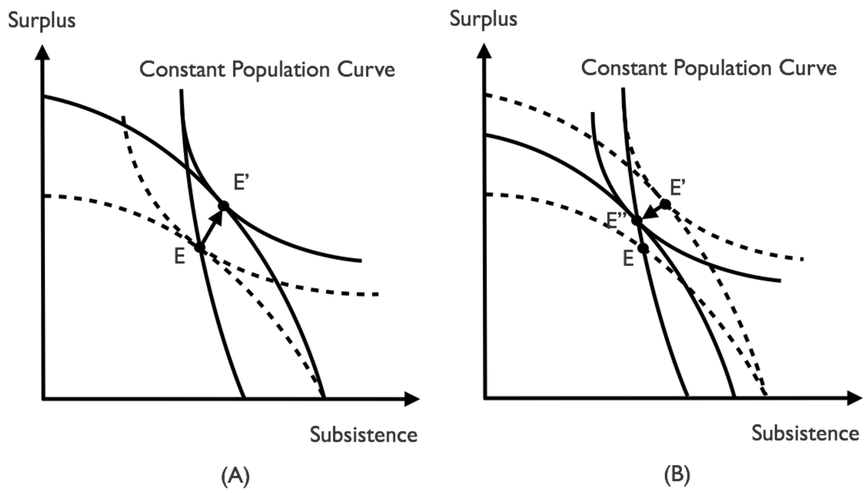

Figure 7: A surplus technology improves the equilibrium living standards.

In contrast, a subsistence technology causes living standards to decline. In figure 8A, the production possibility frontier expands horizontally as subsistence sector expands. The abundance of subsistence triggers the rise of population. After the economy returns to the constant population curve, the new equilibrium stays below the old one, because the production possibility frontier becomes flatter by the influence of subsistence technology. In the long run, what matters for living standards is not the size but the shape of the production possibility frontier.

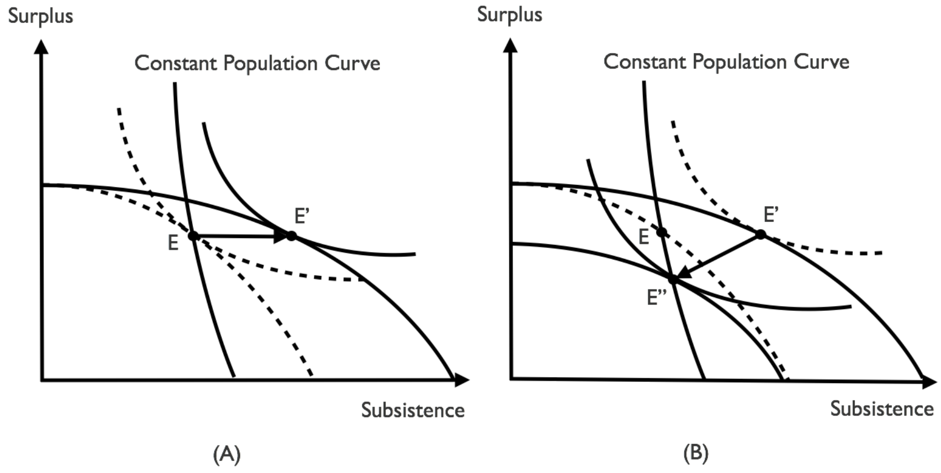

Figure 8: A subsistence technology lowers the equilibrium living standards.

Culture affects the equilibrium as well. Suppose there appears a surplus culture. It tilts the indifference curve into a flatter one (figure 9A). By trading subsistence for surplus, people undergo a gradual decline in population. But when the adjustment is over, the remaining population enjoy a higher equilibrium living standard than in the old days (figure 9B)).

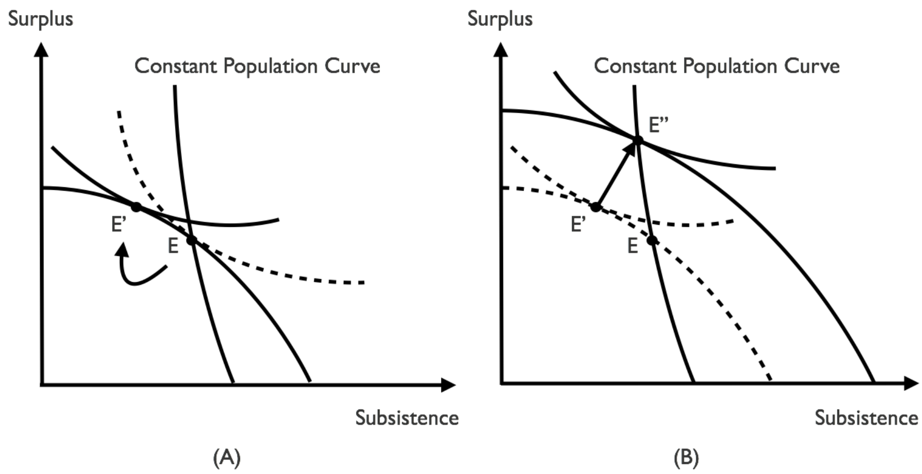

Figure 9: The surplus culture improves the equilibrium living standards.

The above results seem to suggest that a more surplus-oriented production structure is always associated with a higher living standard; and so is social preference. Unfortunately, exception exists: figure 10 shows the scenario where a surplus economy turns out to have a lower living standard.

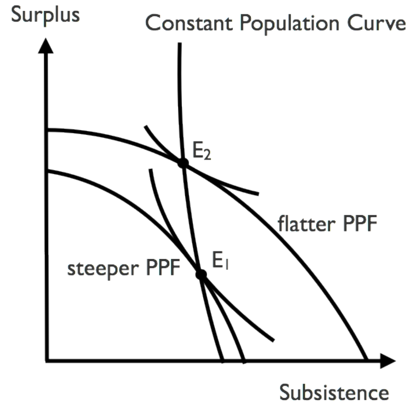

Figure 10: Counterexample: E_1 has a steeper PPF but a lower living standard.

The exceptions are caused by multiple equilibria. In appendix A.4, I prove the following theorems by a theoretical detour that avoids the ambiguity of multiple equilibria[10]:

Proposition 1 (First Production Structure Theorem) *For an economy on a stable equilibrium, a positive surplus technology shock always improves equilibrium living standard.*

Proposition 2 (Second Production Structure Theorem) *If the subsistence is not a Giffen good, an economy of a more surplus-oriented production structure always has higher equilibrium living standards, other things being equal.*

Proposition 3 (First Free Surplus Theorem) *For an economy on a stable equilibrium, a surplus culture always improves equilibrium living standard.*

Proposition 4 (Second Free Surplus Theorem) *If the subsistence is not a Giffen good, an economy of a more surplus-oriented social preference always has higher equilibrium living standards, other things being equal.*

Thus, we establish two comparative statics - culture and technology, which are missing in Malthusian theory. Moreover, our framework works equally well with the old comparative statics that the classical model has covered. When disease environment worsens, or war becomes more frequent, or people marry later or give birth to fewer, the constant population curve will shift rightward: each bundle of consumption is now related to a lower rate of population growth (figure 11A). The decline of population expands the choice set of an average person, so that the new equilibrium provides a higher living standard than the old one (figure 11B) - the framework preserves the merit of the classical theory.

[10] Appendix A.3 list the assumptions I make.

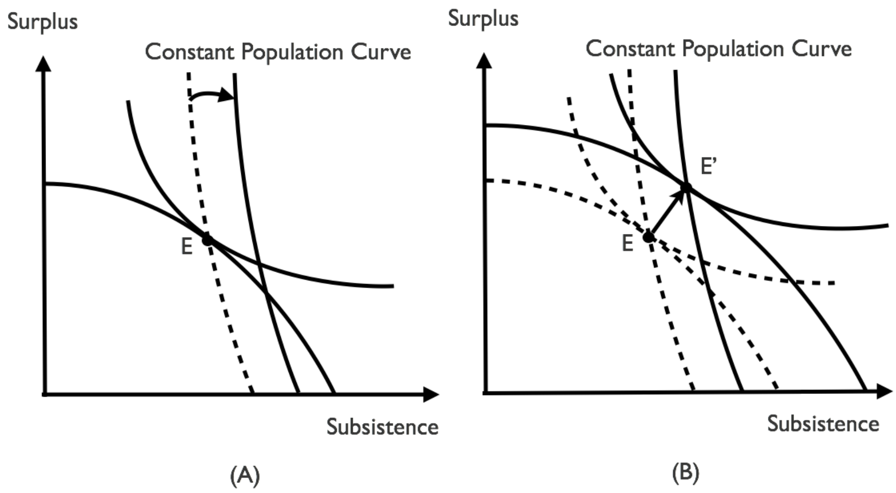

Figure 11: The comparative statics of disease, war and fertility strategy

3.3 The key different assumption

The two-sector model differs from the classical by a single assumption. The classical model does not distinguish surplus from subsistence. There, the constant population curve coincides with the indifference curve. In such a scenario, a surplus technology cannot affect the equilibrium living standards (figure 12). After a surplus shock, when the economy comes back to the constant population curve (figure 12C), the new equilibrium has the same level of utility as the old one. This is because the indifference curve coincides with the constant population curve. As the new equilibrium falls on the constant population curve, it falls on the same indifference curve as well (figure 12C).

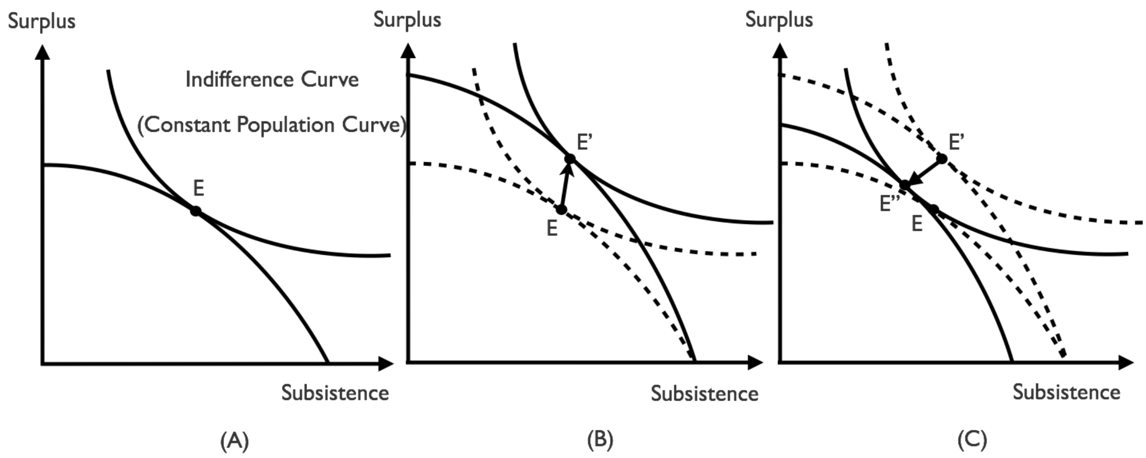

Figure 12: The Malthusian model as a special case

This is why the classical model predicts the constancy of living standards. It is a special case that assumes away the distinction between sectors, assumes away the crossing of curves, and assumes away the conflict of reproductive interest between individual and group. The last point follows the biological nature of the crossing, that in essence, the constant population curve is a curve of iso-group fitness and the indifference curve is one of iso-individual fitness.

By millions of years' natural selection, preference is programmed to maximize one's individual fitness. What pleases is usually what benefits - it benefits the individual but not necessarily the group. So the indifference curve is a close approximation of an iso-individual-fitness curve.

The conflict between group fitness and individual utility - which is manifest in the crossing - is driven by the conflict of fitness between group and individual. Such a conflict prevails in biology as well as in culture. Peacock's tail, redwood's height, bowerbird's nest all are examples. Human welfare and economic growth follow the same principle of evolutionary biology as these phenomena - later, I will explain the analogy in detail. As sure as the fitness conflict persists, the constant population curve crosses the indifference curve; and the distinction of surplus and subsistence is well founded.

3.4 The baseline model

The three categories of comparative statics, each associated to the shift of a curve, can be put into one formula.

Specify the functional forms of the three curves. Let the utility function be Cobb-Douglas and have constant returns to scale on average subsistence x and average surplus y.

$$U(x,y) = x^{1-\beta}y^{\beta}$$

Let the production possibility frontier be the quarter of an ellipse (figure 13). Its size decreases with the level of population H. The maximum average subsistence is $\frac{A}{H}$ and the maximum average surplus at $\frac{B}{H}$:

$$\left(\frac{x}{A}\right)^2 + \left(\frac{y}{B}\right)^2 = \frac{1}{H^2} \ \ (x, y > 0)$$

Let the constant population curve be a vertical line $x = \bar{x}$, so that surplus has no effect on population change.

It is easy to derive the equilibrium level of utility U^*:

$$U^* = \bar{x}\left(\frac{B}{A}\sqrt{\frac{\beta}{1-\beta}}\right)^{\beta} \tag{1}$$

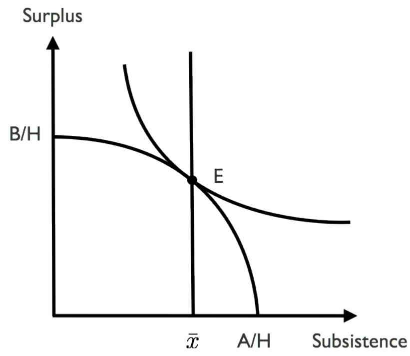

Figure 13: The baseline model

The formula captures all the comparative statics. The equilibrium living standards can rise for three reasons:

1. A rise in the relative productivity of surplus, i.e. $\frac{B}{A}$ rises.
2. A rise in the social preference for surplus, i.e. β rises.
3. A rise in the required consumption for population balance, i.e. $\bar{x}$ rises.

3.5 The puzzle of balanced growth and its explanations

The equilibrium living standards would have grown steadily if the growth rate of surplus had exceeded that of subsistence. To see this, let the group maximum subsistence A grow at the rate of g_A and let the surplus B grow at g_B. At any state, for a population of H, the level of utility is[11]

$$U = \left(\frac{B}{A}\right)^{\beta} \frac{A}{H} \sqrt{(1-\beta)^{1-\beta}\beta^{\beta}}$$

With β as a constant parameter, log linearization gives

$$g_U = \beta(g_B - g_A) + g_{\frac{A}{H}}$$

Measuring utility growth is meaningful because the utility function has constant returns to scale. Appendix A.1 proves that the aggregate subsistence A and the level of population H will grow at the same rate in the long run, $g_{\frac{A}{H}} = 0$. Therefore,

$$g_U = \beta(g_B - g_A) \tag{2}$$

In Malthusian theory, $\beta = 0$: there is only one sector. Therefore $g_U = 0$, the living standards do not grow. In the two-sector model, β is positive; the living

[11]It is not equal to the equilibrium. The constant pull of technological growth causes the economy to deviate from the equilibrium state.

standards will grow steadily unless surplus and subsistence evolve in a balanced way, $g_B = g_A$.

The world population had grown from several million at the dawn of the agricultural revolution, to three hundred million at the birth of Christ, and to almost one billion on the eve of the industrial revolution. So had the aggregate production of subsistence grown in proportion. Now if the living standards had indeed been constant, the surplus sector must have behaved in the same way. But why is so?

I tried quite a few explanations for the balanced growth. Below are the most promising ones.

1. **Evolutionary adaption**

   Long exposure to a commodity causes genetic adaption for people to better use the commodity as a subsistence. Lactose intolerance is relatively rare among North and Western Europeans because their ancestors drank more milk.

   Doubts: Genetic adaption takes too long and is limited to food.

2. **A thing is valued in proportion to its rarity.**

   Diamonds are precious because they are rare. Surpluses become worthless when they are too many. Moreover, lots of surpluses are positional goods: people value how much they own compared with others instead of what they own *per se*.

   Doubts: This might explain why being rich does not make one much happier, but it does not explain why physical deprivation lasts.

3. **Constant returns to scale**

   In a dynamic system such as

   $$\begin{aligned} A_{t+1} &= F_A(A_t, B_t) \\ B_{t+1} &= F_B(A_t, B_t) \end{aligned}$$

   if functions F_A and F_B have constant returns to scale, A and B will grow in balance on a stable path (Samuelson and Solow, 1953).

   Doubts: The theorem Samuelson and Solow proved does not apply to the generation of ideas. I have tried various ways of imposing such a constant-returns-to-scale structure on the dynamics of surplus and subsistence, but none makes sense.

4. **Group selection**

   I cannot reject the explanation. I believe this is the true reason for the Malthusian constancy.

3.6 The source-sink model of migration

What is group selection? The following model illustrates the idea.

Suppose there is a sea of identical villages. All start at the equilibrium state in the beginning (figure 14A). Assume that people migrate freely but never trade across borders[12].

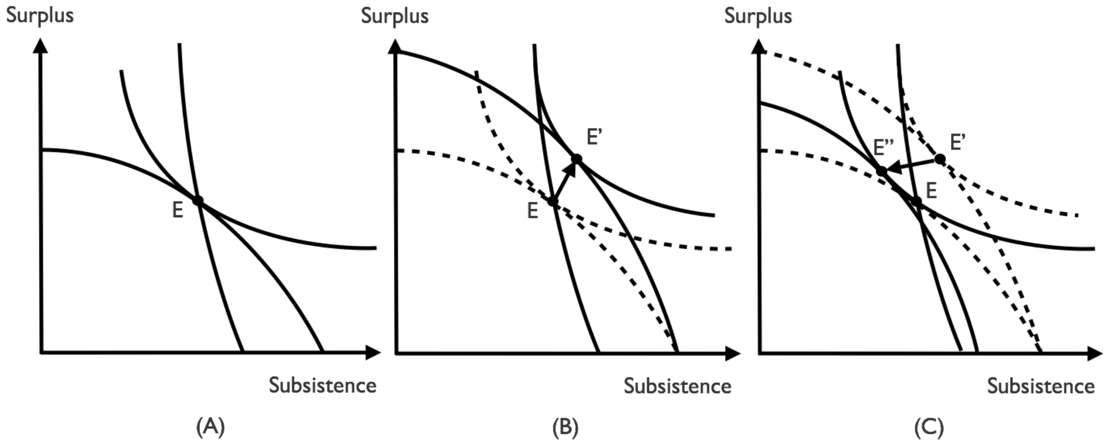

Figure 14: Difference of production structure causes source-sink migration.

Suddenly one of the villages discovers a new way to mine for diamond. Thanks to the surplus technology, its production possibility frontier expands vertically (figure 14B). If migration were forbidden, the diamond village would end up with a higher living standard. But now the immigrants make the level of utility equal between the diamond village and the others (figure 14C).

With its steeper production possibility frontier tangent with the same indifference curve, the diamond village is locked to the left of the constant population curve - its death rate is higher than the birth rate. Despite the natural decrease of population, the production possibility frontier can not expand. It is locked by

[12] If instead the law of one price holds by free trade, people of different areas will face the same budget line. By choosing the same bundle of consumption, they avoid the predicted source-sink pattern of migration. This is why I forbid trade in the model. But the assumption can be relaxed easily. As long as trade is costly - so that relative price differs between regions - the source-sink pattern of migration is always relevant.

the continuous immigration which is ready to fill up the gap created by the under-reproduction of the diamond village. While seeking a better life, the immigrants plunge into a demographic *sink*.

A similar pattern holds for areas that differ in social preference. Again, start with the identical villages at the equilibrium state (figure 15A). Somehow in one of the villages, girls begin to ask for diamonds from their suitors. The indifference curve becomes flatter (figure 15B): people trade food for diamond. If the diamond village could be left undisturbed by immigration, the girls would earn what they demand for free in the end: average grain would barely change.

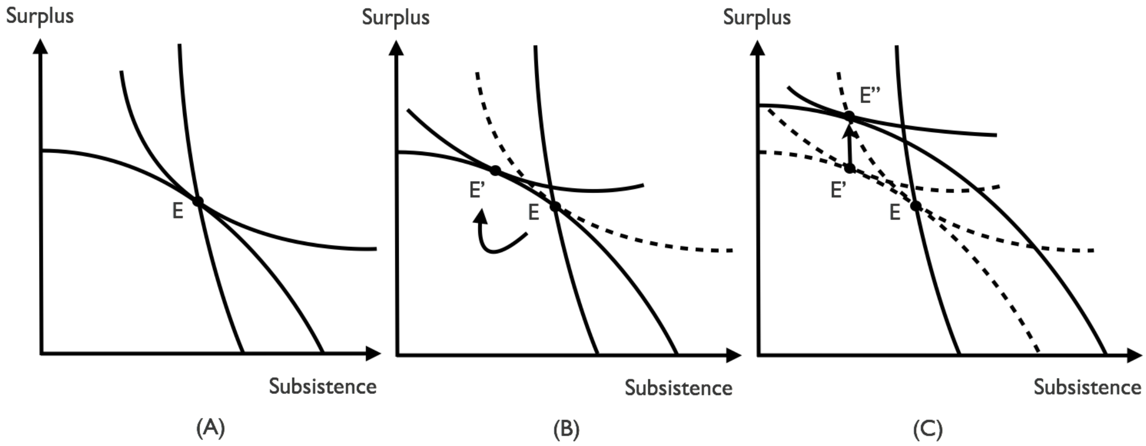

Figure 15: Difference of culture causes source-sink migration.

But immigration changes the picture. The outsiders did not migrate in the beginning. They were less enthusiastic about diamonds. They deemed the diamond village a worse place to live than their home town. But finally, the diamond village exceeds the others in the level of utility, even by the outsiders' standard. That triggers a constant flow of migration. As figure 15C illustrates, the diamond village ends up to the left of the constant population curve - the death rate is higher than the birth rate and the gap is met by immigrants[13].

The craze for diamond will not last forever in the diamond village. The constant flood of immigrants will dilute the diamond culture. This is the fate of most fads and fashion. This is how nature constrains the arms race of conspicuous consumption. Nature constrains it not by the Malthusian force, but by group selection, in the form of source-sink migration.

On the contrary, a subsistence culture can rise to global dominance by sending out emigration (figure 16). Take monogamy as an example. Biologically speak-

[13]The migrants are assumed to keep their old preference. If instead they convert to new culture, the diagram will be slightly different but the source-sink pattern still remains.

ing, the elites would do better under polygamy; they have both the incentive and strength to bolster it. Yet why do most of us live in a monogamous society? My answer is that monogamy is a subsistence culture: by imposing equality of sexual opportunity, it shifts importance from attracting the mates to feeding the children, from a surplus activity to a subsistence one. The local elites' incentive and ability pale in the comparison with the power of group selection.

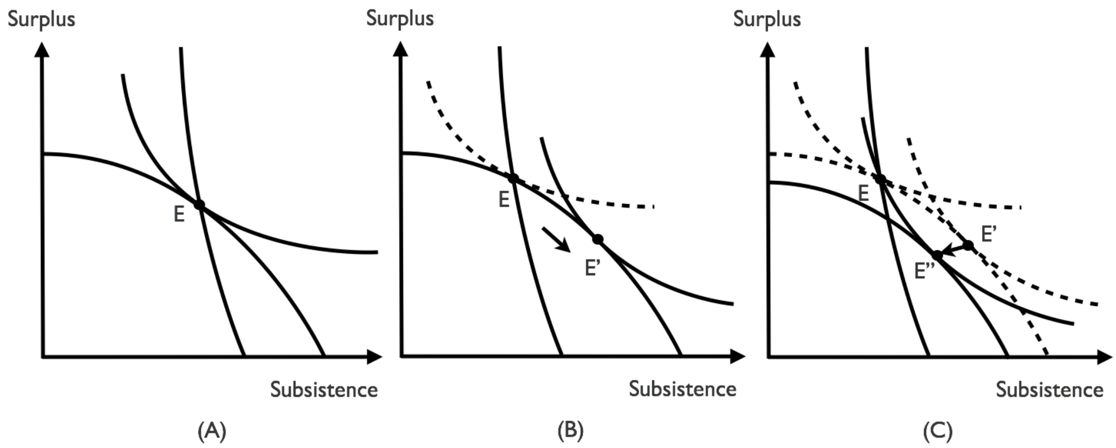

Figure 16: The source-sink migration after a subsistence cultural shock

4 Simulation

4.1 Simulating group selection

Admittedly, reality is more complicated than theory. There exists trade, cross-border learning, seasonal migration and the distribution of books and other vehicles of knowledge. They provide other ways for an idea to spread, ways that are neutral to the surplus character of the idea. For the balanced growth to hold, group selection must overcome these noises. But is selection so strong?

Yes, it is. Simulation shows that group selection quenches the trend of living standards, even if surplus could grow several times as fast as subsistence in an isolated environment. There is little hope of escape from the "Malthusian trap" by ways other than the industrial revolution. In fact, it would be an easy escape if the trap had been merely Malthusian in nature. But the trap is built by the interlock of group selection, which makes it a trap harder to escape from.

To appreciate the strength of group selection, imagine a chess-board-like world divided into 25 grids (figure 17). The baseline model describes everything within each grid: a homogeneous population with Cobb-Douglas utility, a quarter-ellipse production possibility frontier and a vertical constant population curve. A grid economy (i, j) evolves over time with changes in the aggregate subsistence A_{ij}, the aggregate surplus B_{ij} and the level of population H_{ij}.

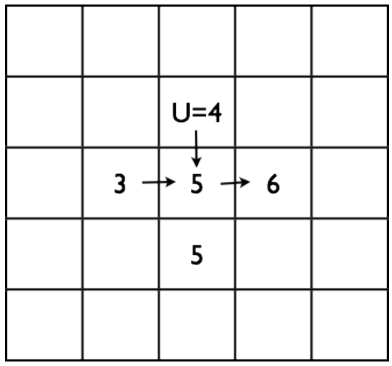

Figure 17: The chess-board world of 25 grids

The subsistence aggregate A of each grid grows at the rate of $T_A + D_A\epsilon_A$, the sum of a constant drift rate T_A and a random fluctuation term. The random part follows a normal distribution, $\epsilon_A \sim N(0, 1)$, i.i.d. and D_A is the standard deviation. Similarly, the surplus aggregate grows at $T_B + D_B\epsilon_B$.

At each period, which is parameterized to be equivalent to a decade, people migrate for a higher living standard. For any pair of bordered grids, if grid 1 has a higher utility than grid 2, the rate of migration from grid 2 to grid 1 is proportional to the utility gap:

$$\frac{\#\text{ of migrants}}{\text{Population of grid 2}} = \theta \ln\left(\frac{U_1}{U_2}\right)$$

The migrants spread knowledge from the source place to the sink place. In simulation, I separately try two different ways of knowledge spread: "pure replacement" and "combining the best".

To illustrate what they mean, suppose England and Ireland both begin with 10 residents. England has 30 units of surplus and 10 units of subsistence; Ireland has 10 units of surplus and 20 units of subsistence. If the utility function is $U = x^{0.5}y^{0.5}$, the living standard is higher in England ($U = 1^{0.5}3^{0.5} \approx 1.73$) than in Ireland ($U = 2^{0.5}1^{0.5} \approx 1.41$). In the next period, a man moves from Ireland to England, in response to the utility gap. Now there are 11 people in England and 9 in Ireland. Since Ireland receives no immigration, it will keep the old levels of surplus and subsistence aggregates. But how does the migration affect the technology in England?

If I assume pure replacement, the Irish immigrant will drag down the surplus aggregate of England and push up its subsistence aggregate. The new English levels will be the following averages, weighted by the composition of population (A denotes subsistence, B surplus and H the level of population):

$$\begin{aligned}A_{ENG} &= \frac{10(\text{ENG A}) \times 10(\text{ENG H}) + 20(\text{IRE A}) \times 1(\text{migrant})}{11(\text{total population})} \approx 10.9 \\ B_{ENG} &= \frac{30(\text{ENG B}) \times 10(\text{ENG H}) + 10(\text{IRE B}) \times 1(\text{migrant})}{11(\text{total population})} \approx 28.2\end{aligned}$$

Pure replacement is a strong assumption. It implies the possibility of technological degradation. Yet it applies to the context of wars. As an extreme form of source-sink migration, war has occasionally caused degradation of technology in history.

Alternatively, we may allow the sink region to combine the best of the immigrants' technology with their own: if the immigrants carry a superior technology, the sink adopts it; otherwise, it keeps the old one. Now the English will compare the Irish technology with their own. The Irishmen have a worse surplus but a better subsistence. Therefore, the English surplus aggregate does not change but the subsistence will be upgraded from 10 to 10.9.

"Combining the best" spreads subsistence, but it never destroys surplus. Pure replacement does both at the same time, which makes it a stronger suppression on surplus. The reality is somewhere in between.

Figure 18 compares the simulated history of utility under different assumptions. I assume the drift rate of surplus T_B is 1% per decade and that of subsistence is half of it, $T_A = 0.5\%$. After 1000 decades, the global average utility grows from 1.5 to 12 if migration is forbidden or if the migrants do not spread technology. Solely the Malthusian force fails to check the growth. In contrast, group selection preserves the constancy of living standards[14]. Under the assumption of either pure replacement or combining the best, the average utility never exceeds twice the original level throughout the simulated history that spans $10,000$ years.

The stability of living standards does not mean stagnancy of technology. In fact, the intense group selection raises the speed of technological progress and hence population growth (figure 19).

Furthermore, group selection disciplines the inter-regional variance of utility. Figure 20 shows the distribution of the regional utility levels. The living standard of the richest place has always been about twice that of the poorest.

Within a grid, the dynamics of utility are more volatile than the global average. Figure 21 illustrates three particular regions: one in the corner, another on the side

[14] To avoid a downward trend, the drift rate of surplus T_B is assumed to rise sharply as the ratio of B/A gets close to 0.

$$T_B = T'_B \left(1 + \left(\frac{B}{A}\right)^{\alpha}\right) \tag{3}$$

I make the parameterization $\alpha = -10$ to minimize the effect of the assumption.

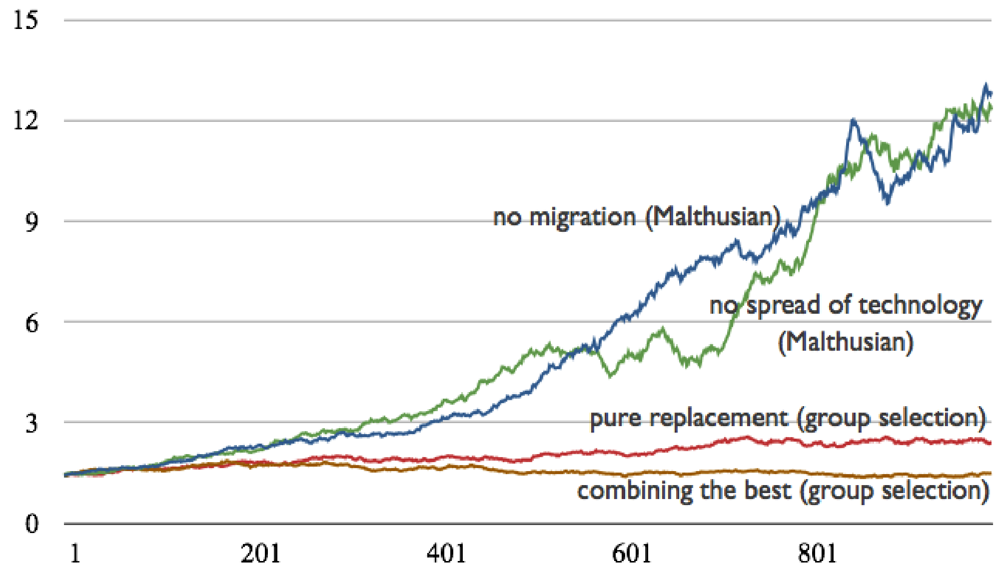

Figure 18: The evolution of utility under different assumptions

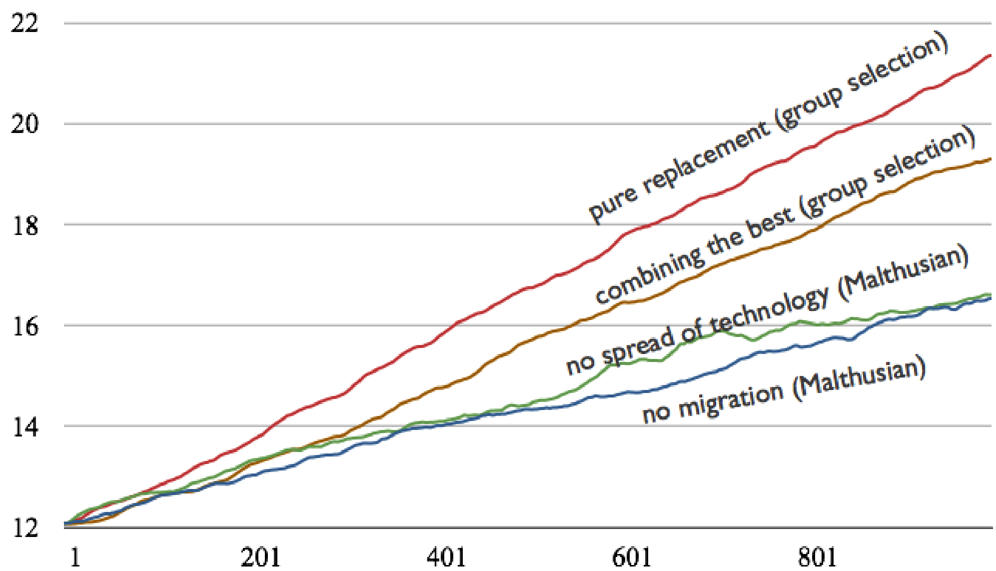

Figure 19: The population growth under different assumptions (log)

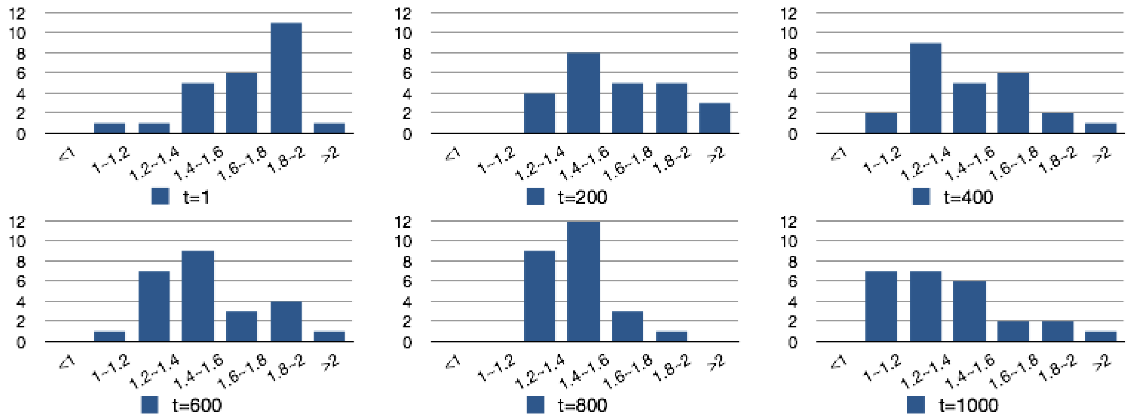

Figure 20: The evolution of the distribution of utility (pure replacement)

and the other in the center. Despite the wild fluctuations of utility - even with cycles that span thousands of years - there is no trend in any of the three regions.

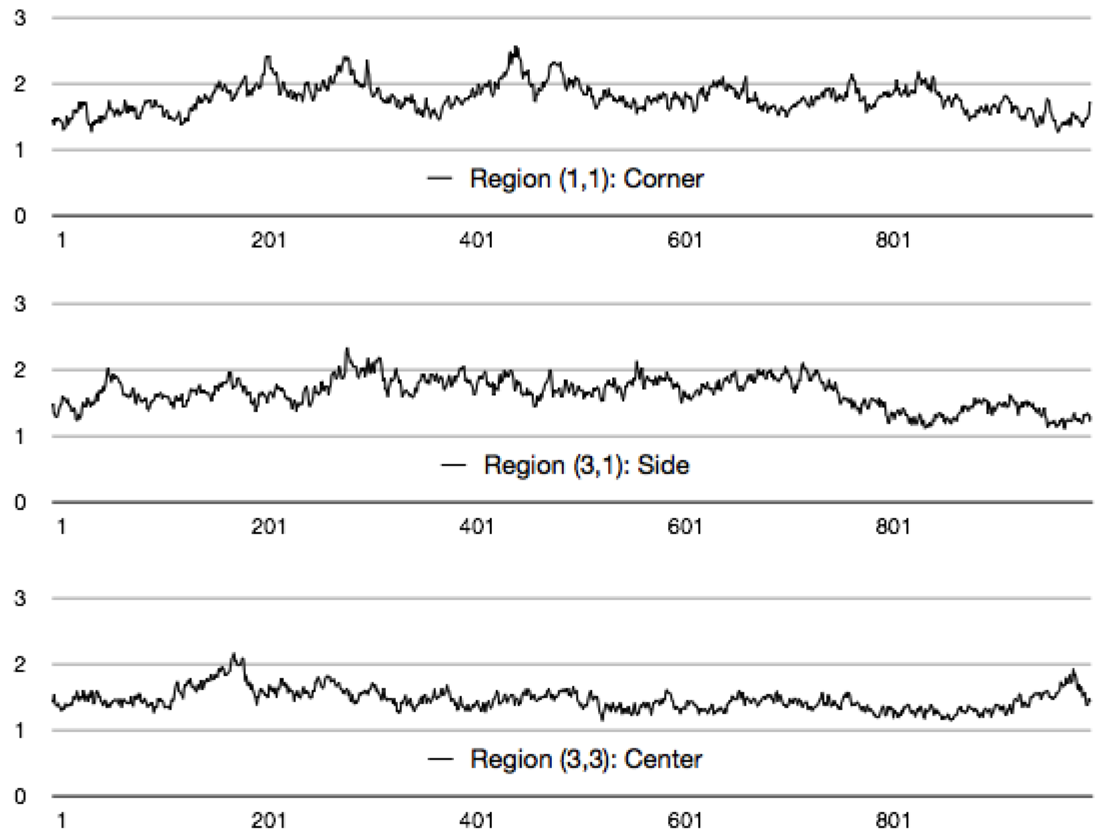

Figure 21: The evolution of regional utility

4.2 Robustness

How robust is the result? To answer the question, I vary the key parameters and observe how they affect the trend of growth. There are two set of key parameters: the relative growth rate of surplus ($T_B - T_A$) and the standard deviation of the growth rates (D_A and D_B). The standard deviation is important because selection works on variation: a larger variation across the regions allows more intense selection.

For the robustness test, I fix the drift rate of subsistence at $T_A = 0.5\%$. Then I vary the drift rate of surplus T_B from 0% to 2%, and the standard deviations - both D_A and D_B - from 0% to 15%, assuming $D_A = D_B$. For each pair of parameters T_B and $D_A(D_B)$, I run a simulation that spans 600 decades on a world that is divided into 10 by 10 grids. I record the growth of utility from the 301st decade to the 600th decade. If the global average utility rises more than 25% within the 300 decades, I mark a triangle on the space of parameters; otherwise, I mark a circle.

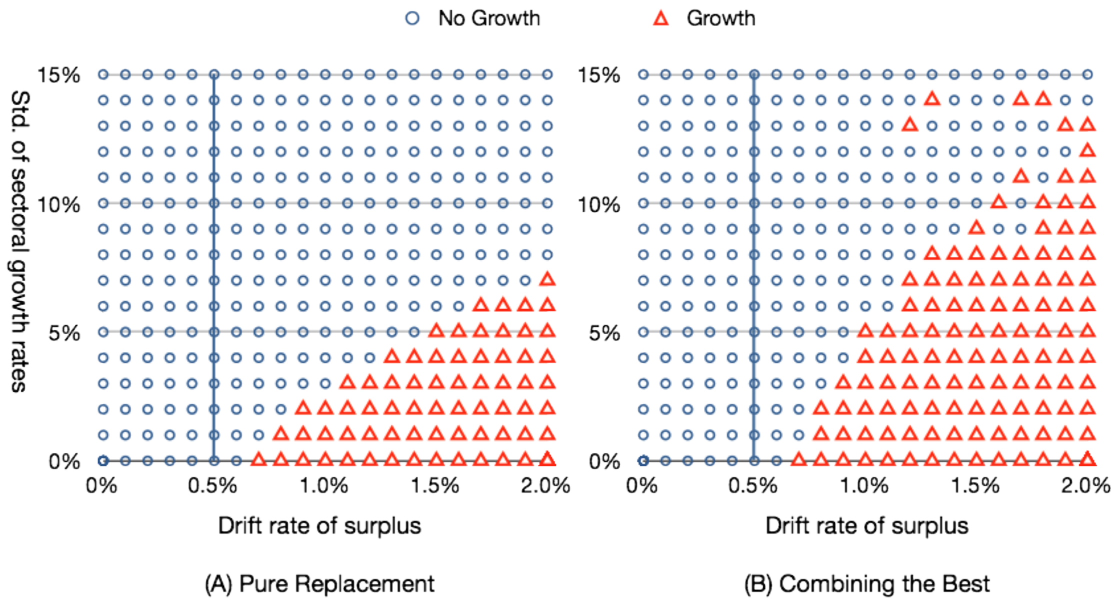

Figure 22: Robustness check

Figure 22 shows the results under "pure replacement" and "combining the best". Selection works on variation: growth is less likely to appear with a larger variation of growth rates. With enough variation, group selection can dominate a significant growth advantage of surplus. For example, under the assumption of pure replacement, when the change rates of technology have a standard deviation of 5% per decade, the cumulative growth of 3000 years is less than 25% even if the surplus aggregate drifts up at the rate of 1.4%, almost three times as fast as the subsistence aggregate (0.5%).

The constancy of living standards requires surplus to grow at the same rate as subsistence in the long run. But the mere equality of long-run average growth rates is not enough. World population growth had accelerated for several times, which implies the acceleration of subsistence (figure 23). Can surplus growth catch up with subsistence growth at each time when the accelerations occur?

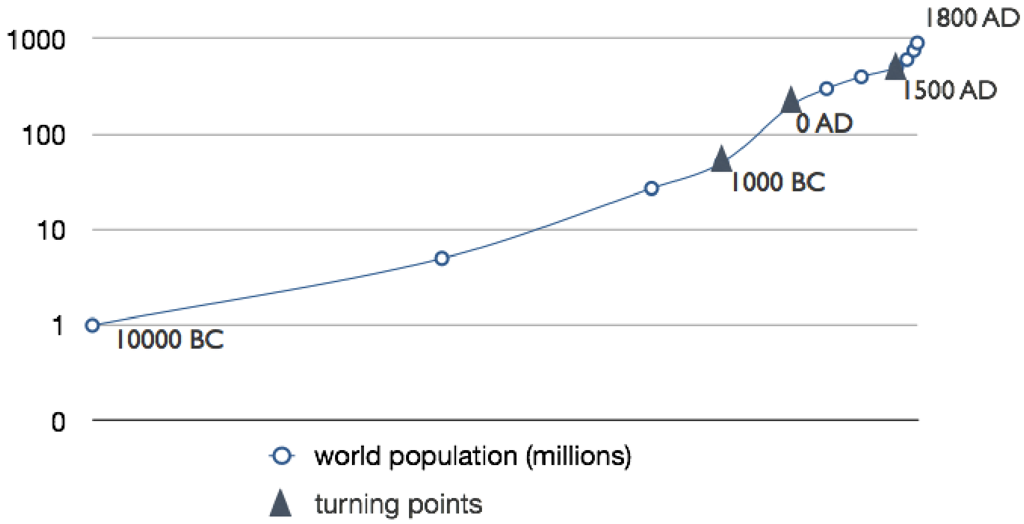

Figure 23: The historical world population, from 10000 BC to 1800 AD

The answer is yes. Surplus growth closely matches subsistence growth like a duet dance. I simulated a history of 2,000 decades for a world of 10 by 10 grids. The drift rate of surplus is fixed at 1% throughout; but I make the drift rate of subsistence jump from 0.25% to 0.75% at the 1001st decade - a kink appears in the path of global subsistence aggregate (figure 24).

Now I conduct a Chow test to check whether the path of surplus shows a kink at the 1001st decade as well:

$$\Delta \log(\text{Surplus}) = \underset{(1e^{-3})}{5e^{-3}} + \underset{(0.6e^{-3})}{10e^{-3}} \times \text{break dummy} + \epsilon$$

The test yields a p-value as low as 10^{-6}, rejecting the null hypothesis of no kink. Notice that the estimated coefficient of the break dummy is exactly twice as large as the constant term. It means that when the growth rate of subsistence triples, the growth rate of surplus triples as well. The catchup happens in spite that the drift rate of surplus has been fixed.

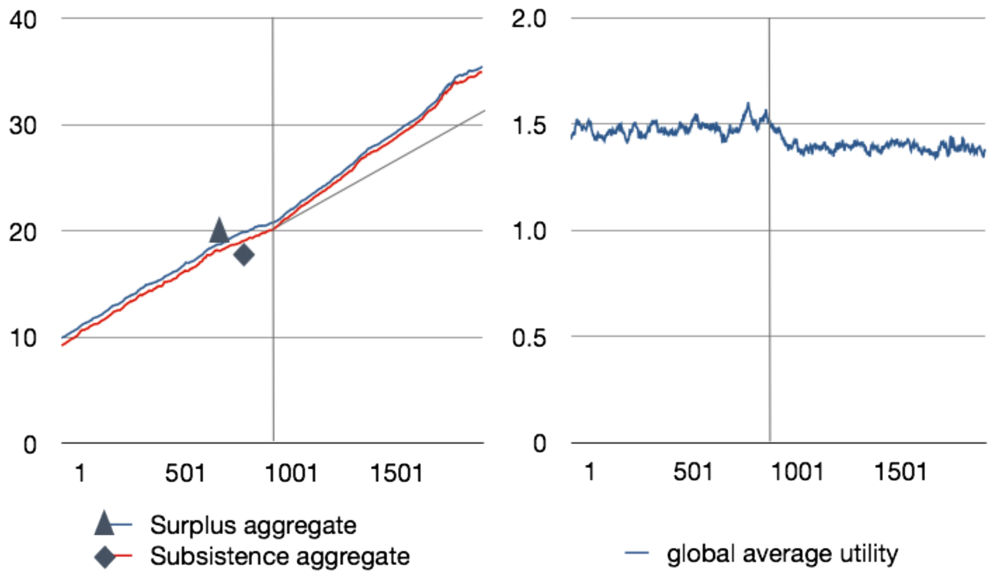

Figure 24: The duet dance between surplus and subsistence

5 Evidence

Empirically, the theory relies on three things. First, some goods should have a larger effect on the growth of population than the others. Second, there should exist the source-sink type of migration in history. Third, migration and wars should hinder surplus booms.

5.1 The empirical division of surplus and subsistence

To establish the first fact, I turn to the English price series collected by Gregory Clark (2004). I use the "affordability" of different goods to explain the birth and death rates between 1539 and 1800[15].

I calculate the indices of "arable wage" and "pasture wage" for the measure of affordability. The arable wage, for example, is the ratio of the nominal average income to the price index of arable goods[16]. It measures the maximum amount of arable goods that an average person could buy with all her income.

I regress the annual birth and death rates on the wage indices and other con-

[15] Wrigley and Schofield (1981) estimated the annual numbers of baptisms and burials in England. The series is the most commonly used in the modern literature on English demography.

[16] Arables include wheat, rye, barley, oats, peas, beans, potatoes, hops, straw, mustard seed and saffron. Pastures include meat, dairy, wool and hay, of which meat includes beef, mutton, pork, bacon, tallow and eggs. Clark (2004) compiled the annual price series for most of the products. He also derived aggregate price indices of arables and pastures.

trols[17]. But an ordinary least square regression would give biased estimates of the standard errors. The series of the birth and death rates have serial correlation. Their patterns of autocorrelation and partial autocorrelation (figure 25) bear the signature of a first-order auto-regressive process. Therefore, I use the Newey-West method for the consistent estimation of the standard errors.

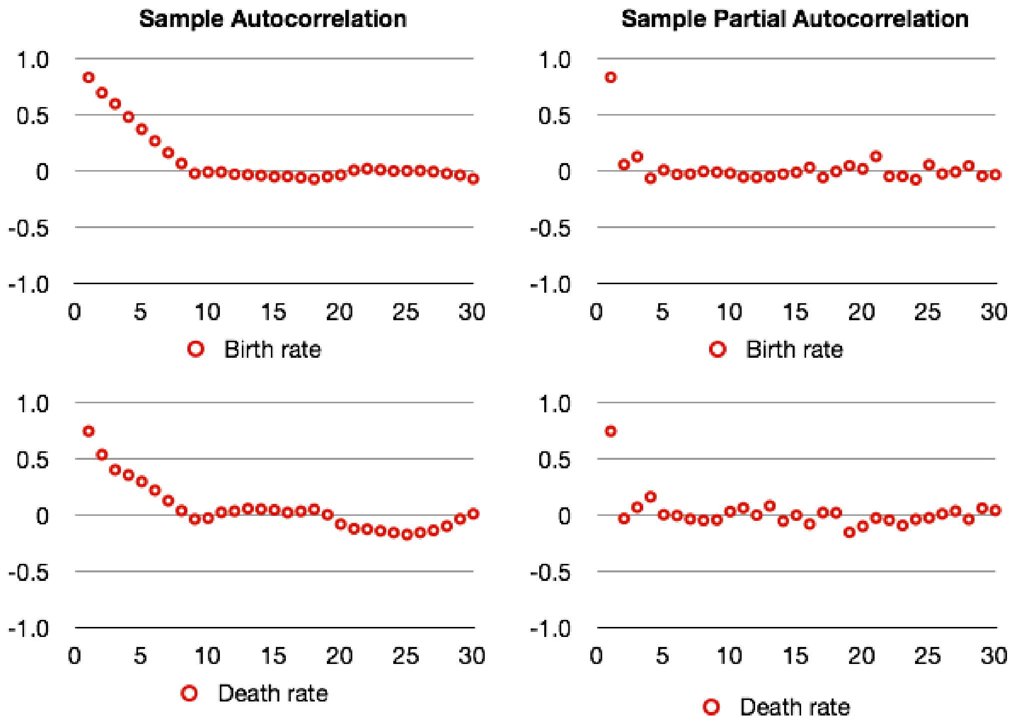

Figure 25: The sample autocorrelation of the annual birth rate and death rate

With the guide of the Akaike information criterion, I choose to run the regressions up to four years' lags. But I only report the cumulative dynamic multipliers that sum up this year's effect and the last year's effect. In the data, an event that happened two years before hardly affects this year's birth and death, after controlling for the current state of the economy.

I conduct three experiments with six pairs of regressions. Table 1 and table 2 show the results.

In the first experiment, I compare the effects of the arable wage and the pasture wage (columns $B(1)$ and $D(1)$). The arable wage has significant effects on both the birth rate and the death rate. If doubled, it would raise the birth rate by 0.38 percentage points and lower the death rate by 0.73 percentage points within two years. In contrast, the pasture wage has no significant effect on either of the rates. Such a difference is not caused by the difference of sectoral size - the pastures as a

[17] I control for the climate with data from Booty Meteorological Information.

Table 1: What affects the birth rate?

Dependent Variables	Birth rate (%) (mean=3.31)					
	B(1)	B(2)	B(3)	B(4)	B(5)	B(6)
Arable wage	0.38***					
	(0.09)					
Wheat wage		0.00				
		(0.12)				
Barley and Oats wage		0.41**		0.41**	0.52**	
		(0.17)		(0.16)	(0.21)	
Pasture wage	0.02	-0.02				0.00
	(0.26)	(0.21)				(0.25)
Clark real earning			0.76***	0.05		0.77***
			(0.21)	(0.33)		(0.18)
Wrigley real wage					-0.39	
					(0.27)	
R^2	0.65	0.67	0.63	0.66	0.64	0.65
Observations	262	262	262	262	257	262

Notes: All the coefficients are the sum of this year's and the last year's effects. The models control for the linear, quadratic and cubic trends and include the climate and plague dummies up to two years' lags. *,** and *** denote significance at the 90%, 95% and 99% levels respectively.

Table 2: What affects the death rate?

Dependent Variables	Death rate (%) (mean=2.75)					
	D(1)	D(2)	D(3)	D(4)	D(5)	D(6)
Arable wage	-0.73**					
	(0.33)					
Wheat wage		0.14				
		(0.24)				
Barley and Oats wage		-1.07**		-1.18**	-1.25**	
		(0.52)		(0.59)	(0.55)	
Pasture wage	-0.35	-0.08				-0.5
	(0.52)	(0.48)				(0.5)
Clark real earning			-1.42**	0.55		-1.12*
			(0.64)	(0.8)		(0.62)
Wrigley real wage					0.76	
					(0.49)	
R squared	0.34	0.39	0.30	0.37	0.37	0.34
Observations	262	262	262	262	257	262

share of economy had been about 3/4 as large as the arables. Rather, it is evidence that the arables are a relative subsistence to the pastures.

The second experiment (columns $B(2)$ and $D(2)$) shows that even within the category of arable goods, barley and oats are a relative subsistence to wheat. In pre-modern England, wheat had been a more expensive source of calorie than barley and oats. The rich had wheat bread while the poor ate porridges. Combined, barley and oats were smaller than wheat as a share of economy, but the barley and oats wage has a much larger impact on the birth rate and the death rate.

In fact, the barley and oats wage explains most of the demographic effect of the average income. Compare $B(3)$ with $B(4)$ and $D(3)$ with $D(4)$. Adding the barley and oats wage as a regressor causes the coefficients of the real income to lose all the significance. But adding the pasture wage has no effect at all - columns $B(6)$ and $D(6)$ report the results of the pseudo test. Merely having a 10% share of the English economy, barley and oats exerted a more significant impact than all the other goods combined. The pattern is robust. It holds when I replace Clark's series of real earning with Wrigley's series of real wage (columns $B(5)$ and $D(5)$).

5.2 The magnitude of source-sink migration

The empirical division of surplus and subsistence provides basis for the source-sink migration. As production structure changes, the equilibrium varies in a wide range. It causes gaps of utility between different places. That triggers the source-sink migration.

The source-sink migration is best documented in the studies of rural-urban migration. Since John Graunt's (1662) pioneering work, researchers have been fascinated by the phenomenon of urban natural decrease. The death rate was higher than the birth rate in the urban areas during the pre-modern era. Moreover, the urban natural decrease often coincided with the rural natural increase. Between the rural and urban areas, there arose a pattern of source-sink migration.

Jan de Vries (1984) summarized the previous studies and decomposed the net change of urban population[18] into the natural change and immigration. As figure 26 shows, during most of the time between 1500 and 1800, urban population had been growing in both Northern and Mediterranean Europe. However, despite the net increase, the urban population had been declining "naturally" - the death rate was higher than the birth rate in the cities. Take the period $1600 - 1650$ for example. During the half century, Northern Europe witnessed an annual growth of 0.32% in its urban population; but meanwhile, the urban death rate exceeded the birth rate by 0.33%. So it took a flow of rural migrants that amounted to 0.65% of the size of the urban population to move into the cities every year.

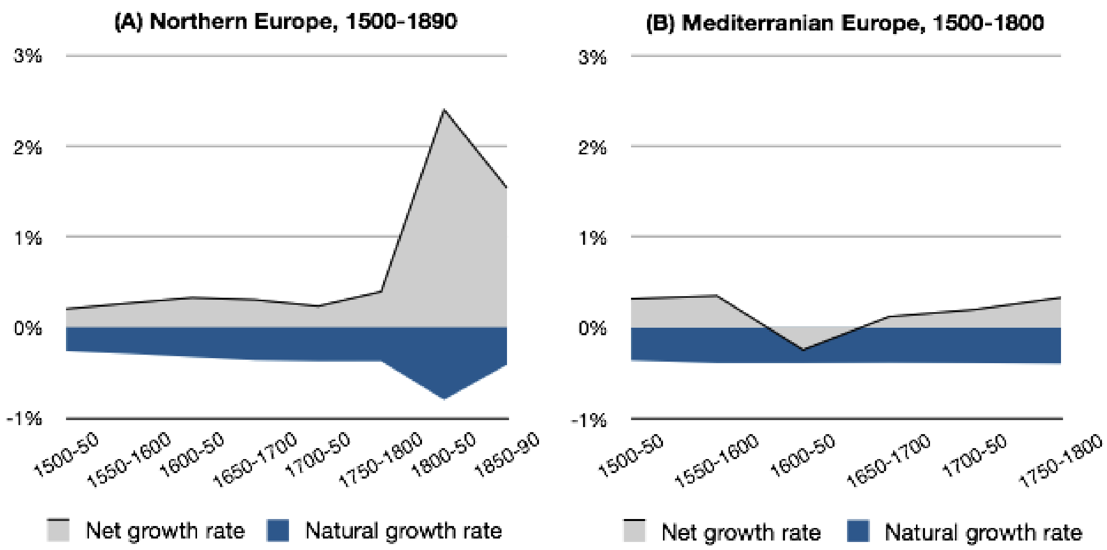

Figure 26: The source-sink migration in pre-modern Europe (De Vries, 1984)

[18] "The European Urbanization, 1500-1700", p. 203 and p.208.

The pattern of migration exposes the limitation of Malthusianism. Between 1800 and 1850, there was a spike in the growth of urban population in Northern Europe. It suggests a rise in the urban living standards. The Malthusian theory predicts that a higher living standard would raise the natural growth rate of population. But in fact, the half century of 1800-1850 witnessed a widened gap between death rate and birth rate.

The Malthusian theory cannot account for the contradiction, but my theory can explain it easily. In the years after 1800, manufacturing and commerce grew fast in the urban areas; and agriculture grew fast in the rural areas. The rural-urban difference of production structure was widened, so that the urban lifestyle attracted more immigrants than in the centuries before. The flood of immigrants lowered the average subsistence by so much that the natural growth rate of the urban population decreased further. The wider the difference of production structure, the deeper the sink of demography. Appendix A.2 proves it as a theorem.

5.3 Selection against surplus boom

Surplus promotes individual fitness at the expense of group fitness. Group selection against surplus is tautological. What matters is the frequency, intensity and impact of the competition between groups and peoples.

Fatal clashes between groups are a perpetual human condition. Of the fourteen groups studied in Mae Enga - a modern hunter-gatherer society in Papua New Guinea, five went extinct in tribal clashes over a 50-year period (table 3). With such an extinction rate, group selection works harshly against surplus cultures and technologies.

Table 3: Group extinction rates for five regions of Papua New Guinea and Irian Jaya

Region	Groups	Extinctions	Years
Mae Enga	14	5	50
Maring	32	1-3	50
Mendi	9	3	50
Fore/Usufura	8-24	1	10
Tor	26	4	40

Notes: the table is taken from Soltis et al. (1995), table 1.

The agricultural revolution demonstrates the strength of group selection. Despite its negative effect on living standards, agriculture steadily encroached on the hunter-gatherer territory as a subsistence technology.

After the agricultural revolution, the world was divided into the nomadic zones and the arable zones. Clashes between the two disrupted economic growth over and over again.

Around 1000 BC, the nomads from the hinterland of Europe destroyed a number of highly developed kingdoms in Levant and Anatolia. The Hittites, the Minoans, the Mycenaeans lost the complex social order they had built. Urban centers, artistic representation, elaborate writing system, large-scale trading, shipping and construction vanished; civilizations were reduced to impoverished, illiterate, technically backward and more violent small communities. Underlying the economic decline is the pattern of source-sink migration - "the invasions were not merely military operations, but involved the movements of large populations, by land and sea, seeking new lands to settle. (Bryce, 1998)"

Similar examples are numerous. The fall of western Rome under the Visigoth and Hunnish intrusion, the overwhelming victory of the barbarian Jin over the civilized Liao empire, the Mongol destruction of Baghdad - the "center of learning" and then the largest city of the world - all exemplify the intense group selection that suppresses surplus economies.

Moreover, people respond to selection by intentionally cutting down surplus for group survival. For example, the warring period of China (476 BC - 221 BC) witnessed a series of reforms in different kingdoms[19]. In response to the constant nomadic harassment, King WuLing of Zhao (340 BC - 295 BC) commanded his subordinates to take off the conspicuous dress of wide sleeves and long robes and switch to the nomadic uniform - pants, belts and boots. Besides, he transformed the backbone of his army from chariots to cavalry, which started a military revolution that quickly swept the other kingdoms. In King Wuling's lifetime, Zhao defeated three nomadic tribes - Zhongshan, Loufan and Linhu and became a serious rival against Qin, then the strongest kingdom.

Half a century before Zhao's reform, Qin rose to dominance by *Shang Yang*'s reforms in 356 BC and 350 BC. The reformer punished merchants, rewarded peasants, forbid migration, restricted entertainment and adopted censorship - in a word, he cut down surplus and promoted subsistence. The living standards declined so much that the Qin people would emigrate whenever they could evade the severe punishment of law. But after the reform, Qin stood out to be the strongest state. It defeated all the rivals and united the whole country in the end.

A contemporary philosopher, Xun Zi (313 BC - 238 BC) commented on the

[19] To name a few, Li Hui conducted a reform in Wei, Wu Qi in Chu, Shen Buhai in Han, Shang Yang in Qin and King Wuling in Zhao.

military systems of Qi, Wei and Qin, saying, "Qi trades with the soldiers for the enemy heads they cut down. Its army might deal with a feeble opponent, but not a strong force. Wei holds contests among soldiers and grants tax immunity to the winners. Such practice erodes the tax base of the state. Qin is different. The people are poor and the government is cruel. Whoever hopes for a better life can do nothing but combat hard. This makes Qin army the strongest of all.[20]"

Qin's ideas of governance had a lasting impact on the later Chinese dynasties. They are in sharp contrast with Adam Smith's understanding of national wealth. Scholars before Adam Smith did appreciate market economy and division of labor, yet they valued agriculture more than commerce and manufacturing and frequently advocated restriction on trade and private property, because their goal was not the individual's welfare but the group's survival and expansion.

Adam Smith is unique not because he had a new theory that no one had raised before, but because he lived on the eve of the modern era, when individual welfare is reconciled with group survival and expansion. The following section elaborates on this point.

6 Discussions

6.1 Smithian policies in Malthusian era

Published in 1776, *The Wealth of Nations* heralded the ending of the humdrum Malthusian period. Some Malthusian followers might believe Adam Smith to be ahead of his time. They doubt the Smithian policies can ever affect the equilibrium living standards in the ancient times. In *A Farewell to Alms*, Gregory Clark said "[I]n 1776, when the Malthusian economy still governed human welfare in England, the calls of Adam Smith for restraint in government taxation and unproductive expenditure were largely pointless. ... [while] those scourges of failed modern states - war, violence, disorder, harvest failures, collapsed public infrastructures, bad sanitation - were the friends of mankind before 1800."

But my thesis is that Smithian policies can make a difference, both in the short run and in the long run. Adam Smith advocated laissez-faire, light tax and division of labor. Applying these ideas will raise productivity of all sectors, but manufacturing and commerce benefit more from them than agriculture does. As the relative productivity of surplus increases, the economy enjoys a higher equilibrium living standard. This explains the prosperity of ancient market economies.

In contrast, the Malthusianists treat the prosperity of Roman empire and Song

[20] An excerpt from *Xun Zi*, chapter *Yi Bing* (On Wars).

dynasty as a temporary "disequilibrium": an ephemeral carnival before population grew to a new equilibrium. They have used the wrong model. Not all economic booms began with a blessed burst of disease like what happened to Northwestern Europe after the Black Death. Peace and order were more important than mice and flee to the prosperity of Roman Empire and Song Dynasty. When those civilizations unfortunately collapsed, they collapsed not because they reached some equilibrium, but because they disregarded the values and virtues upon which their glory had been founded, because of intervening governance, heavy tax and disruption of trade, because of political disorder within and military threat without.

As of the "friends of mankind" - wars, violence, disorder and collapsed public infrastructures, they destroy more surplus than subsistence. They caused the living standards to rise for a short while and then decline to a lower equilibrium in the long run. This is why it took more than a thousand years for Europe to economically recover from the collapse of Roman Empire.

6.2 Why farm?

The two-sector model also explains why peasants were worse off than their hunter-gatherer ancestors after the agricultural revolution. People had less leisure, worse nutrition and greater inequality after they took up agriculture. In light of our theory, agriculture plays the role of a subsistence technology. By tilting the production structure towards subsistence, it caused the living standards to decline. But

> "Why [should people ever] farm? Why [did they] give up the 20-hour-work week and the fun of hunting in order to toil in the sun? Why work harder, for food less nutritious and a supply more capricious? Why invite famine, plague, pestilence and crowded living conditions? (Harlan, 1992)"

Group selection answers the questions. Although hunter-gatherers enjoyed a better life, they achieved their welfare by living a surplus lifestyle at the expense of group fitness. The calorie output of a male hunter was even lower than that of a female gatherer. Scholars hypothesize that men love hunting because they can trade meat for status and extramarital sex. When agriculture appears, the surplus-rich hunter-gatherer societies cannot compete with the groups that have switched to agriculture. The biased migration from the agricultural areas to the hunter-gatherer areas completed the transition.

6.3 Surplus explosion and the industrial revolution

But how did the mankind finally break the shackle of group selection? How did the industrial revolution happen? My theory provides a new perspective - the theory of surplus explosion. I will develop the theory in the other chapters of my dissertation[21]. Here let me sketch the idea briefly.

Group selection constrains surplus and spreads subsistence. A commodity or behavior can burst into wide adoption when it changes from a surplus into a subsistence. I call such transitions a surplus explosion. For example, agriculture first arose for the production of status goods (Mithen, 2007) - the tribal elites cultivated "crops" for festivals and ceremonies. In the beginning, such agricultural practice was less efficient than hunting and gathering in producing calorie - it was a local surplus activity that was constrained by group selection. But over time, the domestication process raised the calorie productivity of the "status crops". Cultivating crops became more efficient than hunting and gathering. At that stage, agriculture switched from a surplus into a subsistence, and won over the power of selection to help it spread to the rest of the world.

Similarly, the domestication of horses into a tool of war was a surplus explosion that happened in Caucasian steppe. The people that first domesticated horses spread fast by military conquests. Caucasia became the origin of Indo-European language family.

Likewise, Alexander the great spread hellenism by march and conquest. His army inherited military techniques from the constant wars between Greek city states in the older generations. The war skills turned from a surplus into a subsistence as Macedon united Greece.

The industrial revolution follows the same pattern but with a different kind of surplus. Recent theories highlight the rising importance of the quality of children - or human capital - as the pivot of transition[22]. Either by genetic drift or population growth, what used to a surplus - human capital - turned into a subsistence. It helped a state make scientific discovery, achieve technological progress, defended its territory and sent out colonists.

Surplus explosions have happened many times before. Among them, the industrial revolution is unique by its content of surplus. The usual surpluses, diamonds and yachts cannot switch into a subsistence; weapons can switch but it cannot promote economic welfare. Human capital in scientific knowledge is different. With a persistent effect on economic growth, it strengthens the countries rich in it and

[21] The other two chapters are "Institutional Selection and the Burst of Growth" and "Horse, Agriculture, Islam and Science: Surplus Explosions in Human History."

[22] Galor and Moav (2002), Galor (2002), Clark (2007) and Galor (2011)

brings about universal welfare and steady progress.

6.4 The Evolutionary Biology of Economic Welfare

One of the themes of the paper is that economic welfare is an evolutionary biological phenomenon. It is rooted in the conflict of reproductive interest between individual and group. The conflict gives rise to surplus traits in plants and animals, the traits that help the individual compete with the others, but divert resources from supporting a denser population.

For example, peacocks bear the extravagant tail to signal their physical health to peahens. The tail makes a credible signal exactly because it is a handicap that exposes the owner to a greater risk from predators. The density of peacocks would be larger if they collectively refrained from the signaling game.

Group selection constrains the animals' conspicuous traits as well as the mankind's surplus consumption. Guppy is a popular aquarium fish species. Wild-type male guppies have colorful splashes, spots and stripes on their bodies to attract females. Researchers move the fish from a high-predator environment to a low-predator one. They find that the male guppies become brighter in color - the pressure on surplus is loosened when group competition is less intense[23].

Personally, I realized the biological analogy at a trip to Muir Woods, a forest 19 kilometers north of San Francisco that features coastal redwoods. The redwoods can grow up to 100 meters high, as they compete intensely with each other for sunshine. The height serves the individual tree's need but it diverts nutrition which could support a denser forest. Individual fitness is valued at the cost of group fitness.

The surplus of human society, the height of redwoods, the tails of peacocks and the colors of male guppy all are governed by the same principle of evolutionary biology: conflict is universal between group and individual, hence surplus is prevalent in nature. Surplus tends to escalate under the force of individual competition, but group selection harshly quenches it.

Economists have understood "conspicuous consumption" for a long time. Thorstein Veblen coined the phrase to describe how retinue and long skirts are used to show off one's wealth, to the effect of attracting mates. Spence (1973) gave the idea a signaling model. Biologists use the model to study sexual competition and conspicuous traits - surplus seems to be all about sex. But in the real world, we rarely associate our passion for art and status with sexual purposes; we do not intend to impress the others as often as we consume surpluses. How can sex explain most of the surplus?

[23]The Guppy Project of University of California, Riverside.

In fact, sexual competition has a far greater scope than signaling games. Complementary to signaling, there is another mechanism of sexual competition that magnifies the conspicuous traits far beyond the level a signaling model would predict. That mechanism is called "Fisherian runaway", first proposed by biologist Ronald Fisher (1915). Under runaway mechanism, a conspicuous trait that is first caused by signaling can run out of control by a positive feedback "runaway" mechanism.

For example, suppose signaling produces a costly male trait - music playing - and a female preference for the trait. At the signaling stage, females value music talents because they reveal one's sense of pitch, which makes a man more effective at hunting. But now, the fact that the other females like the trait gives a female an extra reason to choose a musically talented man: he can pass on his genes of music talents to her son, who in turn will be attractive to the females of the next generation. So the male trait and the female preference coevolve to be strengthened; men become showier and showier and women choosier and choosier. At last, we have talents as great as Beethoven and Mozart. Since the mating choice is two-way between male and female, females develop no less music talents than males; and males are as choosy as females about the music talents in their partners.

Altogether, the positive feedback magnifies the conspicuous traits. Our talents of music are far beyond the explanation of mere signaling. Yet the origin of the traits is still within the domain of sexual competition - Fisherian runaway is a mechanism of sexual competition. The existence of the mechanism suggests, the conflict between group and individual is much more intense than we might think with the signaling view. The distinction of surplus and subsistence is deeply rooted in evolutionary biology.

6.5 Methodology

A believer in Milton Friedman's methodology of positive economics (Friedman 1953) may reject our new theory. Why do we bother to challenge a theory that has precisely predicted the Malthusian constancy? Malthus missed the conflict of reproductive interest, but why should we care about an unrealistic assumption? Didn't Friedman say, the more unrealistic the assumption is, the better the theory?

Friedman is wrong. Besides a successful prediction, there is one more condition for the validity of a theory - the consistency requirement. We can accept an unrealistic assumption, but we cannot accept it if the theory predicts awry when we make the assumption realistic. Friedman himself was using the consistency criterion to attack the traditional view of Phillips curve. When he introduced inflation expectation, the stagflation had not happened yet, but Friedman still figured out the mistake in the conventional wisdom because the traditional theory was not robust to the introduction of expectation, a more realistic assumption.

As Solow (1956) put it, “All theory depends on assumptions which are not quite true. That is what makes it theory. The art of successful theorizing is to make the inevitable simplifying assumptions in such a way that the final results are not very sensitive. A ‘crucial’ assumption is one on which the conclusions do depend sensitively, and it is important that crucial assumptions be reasonably realistic. When the results of a theory seem to flow specifically from a special crucial assumption, then if the assumption is dubious, the results are suspect.”

This paper shows how sensitive the Malthusian theory depends on the one-sector assumption. Since this assumption is dubious both empirically and theoretically, the classical theory is invalid.

7 Conclusion

For more than two hundred years, scholars have taken for granted Malthus's explanation for the constancy of living standards. The conventional wisdom is wrong.

Different from the Malthusian version of human history, this paper suggests the following basic story. There is a world where people live on two things: grain and diamonds. Population rises with grain production, so the average consumption of grain will not change in the long run. But population hardly responds to changes in diamond productivity. So if diamond productivity grows faster than grain productivity, people will live a better and better life by having more and more diamonds. Such had never happened until 1800. Throughout the millennia before that time, the diamond productivity had grown at the same rate as the grain productivity.

The cause of the balanced growth is selection. There are many groups of people on the world. Left alone, each would have developed diamond productivity faster than grain productivity. But there is migration and wars between the groups. When a group is relatively more productive in grain production, each of its member will have a smaller amount of diamonds. So greed drives them to move abroad. As they move, they bring along the technology of their hometown and spread it to the other places. The consequence is, grain technology spreads easily by migration, but diamond technology is hard to disseminate. The spread advantage of grain offsets the growth advantage of diamonds. It traces out a path of balanced growth and keeps the living standards constant all over the world.

The theory has a bunch of implications. Besides explaining the Malthusian constancy, it addresses the empirical weakness of the Malthusian relationship. The correlation between population growth rate and real income is weak because the classical model has missed culture and technology as important shifters of the birth-rate and death-rate schedules.

Taking into account the biased changes of technology, the theory explains the puzzle of the agricultural revolution - why living standards declined and why agriculture dominated the world despite its negative effect on living standards.

The theory also shows that sound economic policies can improve long-run living standards even in Malthusian epoch. What Adam Smith advocated - long-lasting peace, light tax burden, property rights protection and laissez faire - tilt the production structure in favor of surplus. It explains the prosperity of the ancient market economies, including the Roman and Song empires.

Last but not the least, the theory reveals the hidden law of evolutionary biology in understanding economic welfare. The Malthusian constancy, the industrial revolution and the burst of modern economic growth can all be understood in an evolutionary biological framework, with countless analogies in nature.

Altogether, this paper presents a two-sector Malthusian model, a source-sink migration model, a theory of group selection and a sketch of the theory of surplus explosion. These new models and theories are not without limitations. But the limitations suggest future research direction.

For example, I highlight the importance of migration at spreading ideas. Migration favors subsistence and I use it to explain the suppression of surplus. But there are many other ways for an idea to be spread - local learning, seasonal migration, distribution of books and other vehicles of knowledge. These channels do not favor either surplus or subsistence. It is an empirical question whether migration is strong enough to dominate these noises. In the paper, I turn to computer simulations to demonstrate the strength of selection; yet I believe the theory would be much strengthened if there were more evidence on the relative importance of migration.

Moreover, it is hard to categorize military strength to either surplus or subsistence. In fact, military strength is the best example of surplus explosions: it frequently switches between surplus and subsistence. The flexibility makes it hard to interpret the early expansion of Roman Empire. Rome built its military success on advanced weapons and organization of troops, which partly result from its manufacturing advantage and sophistication of governance. It contradicts the rule of surplus suppression. Such exceptions suggest a more complicated reality than is captured by our theory. In my dissertation chapter on surplus explosions, I will develop a more comprehensive framework to understand “the third sector” - the military part of an economy.

Last but not the least, the theory does not say anything about internal disorder.

But internal disorder is no less important than external threat in the decline of civilizations. Internally, social inequality plays a key role in the fate of a society, but I have assumed it away. Of course, merely putting inequality into the Malthusian relationship would be trivial. Instead, in my future research, I shall study the subtle interaction between inequality and the surplus growth. Surplus is meant for signaling one's relative status - there would be no need for surplus in a perfectly egalitarian society. But if inequality runs out of control, social disorder and foreign invasion will disrupt the system. Therefore, lasting economic progress cannot rely on the arms race of hedonism. This marks the difference between the Roman prosperity and the modern economic growth. While the Roman surplus depended on the political elites' licentious spending, the modern growth is bolstered by trade, science, technology and inequality-correcting institutions such as democracy - the merchants' cities outpaced the princes' cities (Delong and Shleifer, 1993). This will be the theme of the second chapter of my dissertation, "institutional selection and the burst of growth".

Appendices

A Proofs

A.1 The balanced growth between subsistence and population on the equilibrium path, i.e., $g_A = g_H$

Population evolves in the following way:

$$H_{t+1} = H_t[1 + \delta(x - \bar{x})]$$

Transform it into a continuous motion equation.

$$g_H = \delta(x - \bar{x})$$

In the equilibrium,

$$x = \frac{A}{H}\sqrt{1-\beta}$$

Substitute it into $g_H = \delta(x - \bar{x})$,

$$g_H = \delta(\frac{A}{H}\sqrt{1-\beta} - \bar{x})$$

Log-linearization gives

$$\frac{\dot{g_H}}{g_H} = \frac{A\sqrt{1-\beta}}{A\sqrt{1-\beta} - H\bar{x}}(g_A - g_H)$$

Since g_A is given, $\frac{\dot{g_A}}{g_A} = 0$. By a phase analysis of g_H and g_A, it is easy to know $g_A = g_H$ at all stable equilibria.

A.2 Increased difference in production structure widens the demographic sink.

Suppose the sink area is a single village with a steep production possibility frontier; and the source area is a sea of identical villages bordering the sink. The "depth" of the sink is measured by the sink's level of average subsistence x^*. The *natural* growth rate of population depends on x^*: $g_{H^*} = \delta(x^* - \bar{x})$.

$\bar{x}$ is the level of subsistence that keeps the population in natural balance. Since the effect of migration is negligible on each of the source villages, the source villages' average subsistence will be at equilibrium, $x' = \bar{x}$. I use prime ($'$) to denote the source villages.

Our job is to solve for x^* as a function of the production structures - $\frac{B^*}{A^*}$ for the sink and $\frac{B'}{A'}$ for the others.

Let the level of utility be equal between the sink and the source villages:

$$\begin{aligned}
\left(\frac{B^*}{A^*}\right)^\beta \frac{A^*}{H^*}\sqrt{(1-\beta)^{1-\beta}\beta^\beta} &= \bar{x}\left(\frac{B'}{A'}\sqrt{\frac{\beta}{1-\beta}}\right)^\beta \\
H^* &= \left(\frac{A'B^*}{A^*B'}\right)^\beta \frac{A^*}{\bar{x}}\sqrt{1-\beta}
\end{aligned}$$

With Cobb-Douglas utility function, people always spend $(1-\beta)$ share of income on subsistence, so that $x = \frac{A}{H}\sqrt{1-\beta}$. Substitute for $\bar{x}$ and we have

$$\frac{H'A^*}{H^*A'} = \left(\frac{A^*B'}{A'B^*}\right)^\beta$$

By $x = \frac{A}{H}\sqrt{1-\beta}$, the ratio of average subsistence is

$$\begin{aligned}
\frac{x^*}{x'} &= \frac{H^*A'}{H'A^*} = \left(\frac{A^*B'}{A'B^*}\right)^\beta \\
\ln(x^*) - \ln(x') &= -\beta\left[\ln\left(\frac{B^*}{A^*}\right) - \ln\left(\frac{B'}{A'}\right)\right]
\end{aligned}$$

The equation relates the gap of average subsistence to that of production structure. The larger the difference of production structure, the deeper the sink. It explains why the the natural growth rate of urban population declined in $1800-1850$ in Northern Europe.

A.3 Assumptions of the two-sector model

I make the following assumptions to prove the production structure theorems and "surplus is free" theorems.

1. **Conflict of interest:** The utility function $U(E)$ is not a transformation of the growth rate of population $n(E)$.

2. **Homogeneity:** People have the same preference.

3. **Strict monotonicity:** The utility function $U(E)$ and the growth rate of population $n(E)$ are strictly increasing in consumption E.

4. **Endowment economy:** Assume an endowment economy where labor is not an input. When the group size is H, the individual choice set is a $\frac{1}{H}$ fraction of the aggregate set of production possibility.

5. **Rank preservation:** If a good is a relative surplus to another at a bundle of consumption E, it is a relative surplus at all bundles of consumption.

6. **Concavity and Continuity:** The utility function is continuous, strictly concave and continuously differentiable. The production possibility frontier is continuous and strictly concave. The production function is the continuously differentiable.

A.4 Proof of the Production Structure Theorems and "Surplus is Free" Theorems

The production structure theorems state that:

1. For an economy on a stable equilibrium, a *positive* shock of surplus technology always improves equilibrium living standard.

2. If the subsistence is not a Giffen good, an economy of a more surplus-oriented production structure always has a higher equilibrium living standard, other things being equal.

The "surplus is free" theorems state that:

1. For an economy on a stable equilibrium, a surplus culture always improves equilibrium living standard.

2. If the subsistence is not a Giffen good, an economy of a more surplus-oriented social preference always has a higher equilibrium living standard, other things being equal.

Proof: As in figure 27A, draw a ray from the origin. Let the angle between the ray and the horizontal axis be $k \in [0, \pi/2]$. The ray crosses the constant population curve at $E(k)$. Since preference is complete, there exists an indifference curve that passes through $E(k)$. Define $u(k)$ as the absolute value of the slope of that indifference curve at point $E(k)$. $u(k)$ varies as k changes.

Then shift the production possibility frontier in proportion to the place where it passes through $E(k)$. Define $p(k)$ as the absolute value of the slope of the production possibility frontier at point $E(k)$. Since production possibility frontier is continuous and strictly concave, $p'(k) < 0$.

The economy reaches an equilibrium if and only if $u(k) = p(k)$. Put $u(k)$ and $p(k)$ on the same diagram as curves (figure 28A). At certain equilibria, such as the second crossing in figure 28A, $u(k)$ crosses $p(k)$ from above. These equilibria are unstable ones. As Figure 28B illustrates, $E(k_1)$ is such an unstable equilibrium: the indifference curve is tangent with the production possibility frontier at that point, $u(k_1) = p(k_1)$. But $u(k) < p(k)$ for k's that are slightly larger than k_1 - the

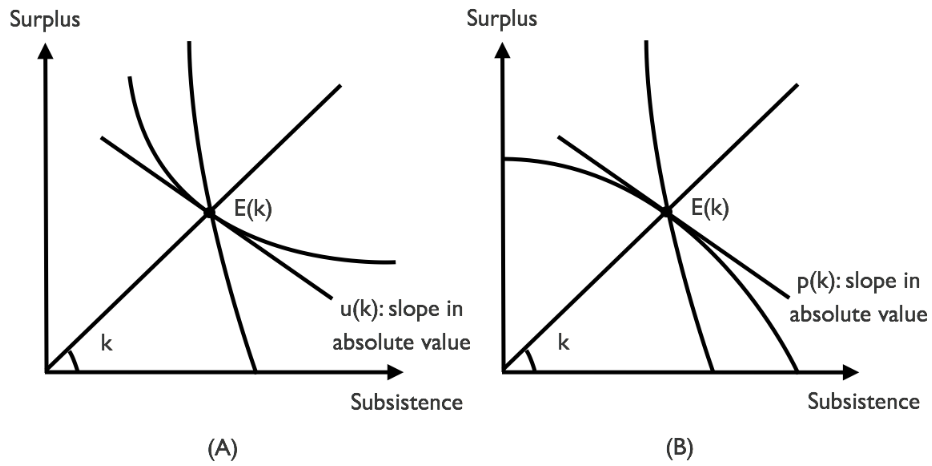

Figure 27: Slope functions: $u(k)$ and $p(k)$

$u(k)$ curve crosses the $p(k)$ curve from above. When a negative disturbance shocks the population, the bundle of consumption will move to the left of the constant population curve (figure 28B). Then it causes further decline of population and makes the economy diverge.

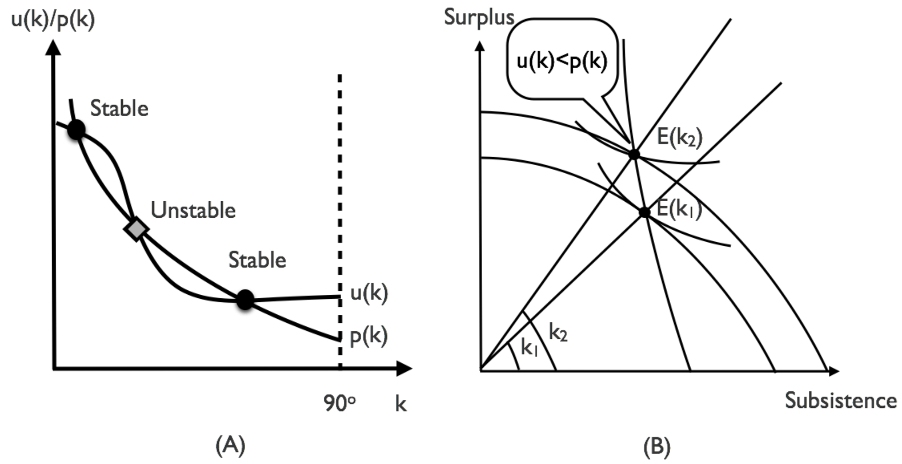

Figure 28: The unstable equilibrium

If there is only a stable equilibrium, it will be easy to show the theorems. When the production structure is more surplus-oriented, the $p(k)$ curve will shift upward: the production possibility frontier becomes steeper. As figure 29A shows, the new equilibrium k_1 will be larger than k_0 and the equilibrium living standard improves. Similarly, when the social preference is more surplus-oriented, the $u(k)$ curve will shift downward: the indifference curve becomes flatter. As figure 29B shows, the new equilibrium has a larger k as well. The equilibrium living standard improves.

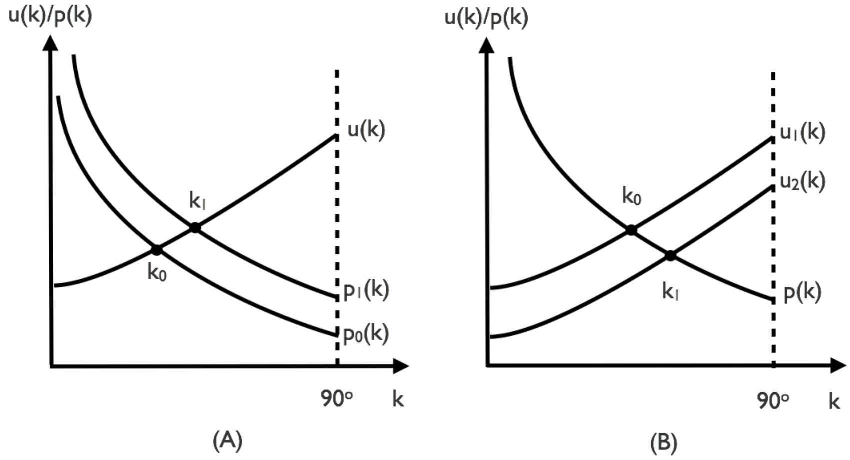

Figure 29: Proof of the theorems

We need a theoretical detour to avoid such "bad" scenarios (figure 30): when the surplus change comes together with a big drop of production, the economy can switch from a superior equilibrium to an inferior one, and the benefit from the surplus change is not enough to compensate the loss. This is why the first production possibility frontier emphasizes "progress", that is, the new choice set contains the old one after the change. Now the equilibrium living standard will improve for sure.

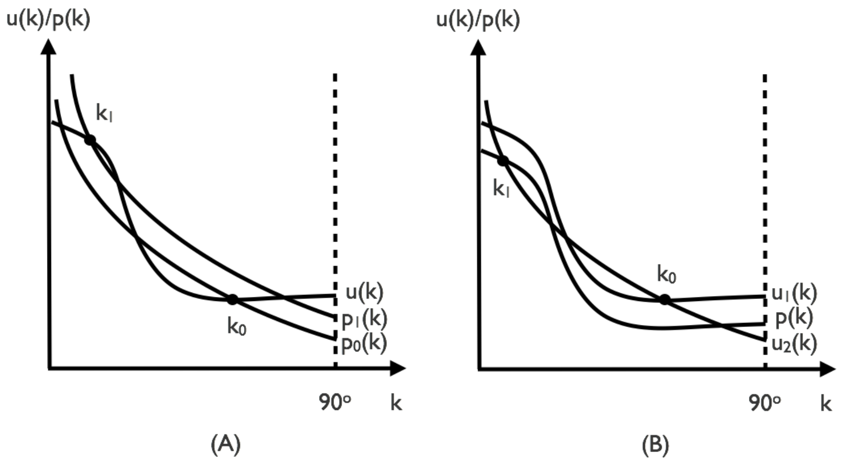

Figure 30: The trouble with multiple equilibria

The second production structure theorem deals with the same problem in a different way. In essence, the multiple equilibria arise partly because subsistence is a Giffen good. When people's income decreases, they spend even more on subsistence. As a result, the level of population becomes even greater after the drop of income.

When subsistence is not a Giffen good, the multiple equilibria can no longer arise.

For the second theorem, we need to prove that the Giffen character of subsistence is a necessary condition. Here is the reasoning. When there exists multiple (stable) equilibria, the economy can always switch from a superior equilibrium to an inferior one. When it does so, $p(k)$ is higher since it is decreasing in k. Though the relative price of subsistence $p(k)$ rises, the equilibrium average consumption of subsistence rises as well - the equilibrium moves downward along the constant population curve. So subsistence is a Giffen goods when there are multiple equilibria. If subsistence is not Giffen, there will not be multiple equilibria and the production structure theorem is proved. The "surplus is free" theorems are proved in the same way.

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