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Analysis of the Great Divergence under a Unified Endogenous Growth Model*

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Recently published research that attempts to explain the Great Divergence mainly focuses on geography, technological progress, and international trade. However, we do not believe these are its only — or even the most basic — causes. Instead, we submit that the 'social culture' of a country or a region is the most fundamental reason and incorporates these other causes, thereby providing a reasonable unified explanation. This paper is mainly based on a very simple two-sector benchmark model that simulates the economic characteristics of England and the Yangzi Delta of China during 1400-1850. It explores aspects of this transition period, and obtains many meaningful results that are consistent with Unified Growth theory, which is usually based on very complex models.

Key Words: The industrial revolution; The great divergence; Difference of culture and systems.
JEL Classification Numbers: O10, O40.

1. INTRODUCTION

In the long history of human development, the world's production and population increased very gradually prior to the nineteenth century. Further, the differences in living standards between countries were very small. However, from 1900 on, the story was different. In some countries, both population and production began exploding in a way that had never before been seen in human history. At the same time, the ratio of the GDP per capita between the richest and poorest regions of the world widened

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considerably from a modest value of 3:1 in 1820 to a value of 18:1 in 2001 (Maddison, 2001). There are two aspects about this economic phenomenon of the last two centuries that have been widely discussed by economists: the Modern Growth (the departure from Malthusian constraints) and the Great Divergence (mainly between Western and Eastern economies). Why? What is the cause for them?

Myriad papers have focused on these questions, and star-studded causes have been espoused for a long time. However, this problem has recently become a hot topic again, and a new development in growth theory — the Unified Growth theory —is underway. The Unified Growth theory [Galor and Weil (2000), Howitt (2000), Jones (2001), Galor and Moav (2002), Hansen and Prescott (2002), Lucas (2002), etc.] aims to offer a systematic explanation for the Modern Growth and Great Divergence by employing one unified economic model. While extant research in this field, taken as a whole, mainly focuses on five causes, viz., geography, human capital, technology progress, cultural institutions, and international trade, each study usually stresses only a single cause. Thus, our questions are as follows. Which of the causes should be the most important one, if there be one such cause? How do the causes work in conjunction with each other? What kind relationship should be among them? A further question that is based on these problems is: Could we develop a really unified model to explain the Modern Economic Growth and the Great Divergence by combining all these most important causes into a systematically developed framework?

On the basis of the above problems, we are planning to study the Great Divergence problem through a modeling approach. Even though some scholars emphasize that models are, after all, only models that can be greatly at odds with reality, many modeling-oriented papers are regarded as having made a great contribution to both economic theory development and a real understanding of problems. We do believe models are the most basic and helpful tools for understanding a supposed case of the development of economic history. Since we have no data on a supposed case of history, any approach that is based on historical data might commit an error of logic, namely, the application of real historical data in the analysis of a supposed case. Thus, a modeling approach might be the only reasonable alternative for studying a supposed case.

This paper aims to study firstly the fundamental reason for the Divergence and secondly whether an Industrial Revolution could have arisen in the Yangzi Delta in China rather than in England during its actual period of occurrence. With regard to the former question, many have stressed the contribution of technological progress and human capital accumulation. For example, Galor and Weil (2000) discuss technology and population, while Lucas (2002) addresses human capital. In the context of other fac-

tors, Galor and Moav (2002) analyze the effect of trade, Howitt (2000), and Aghion (2004) focuse on innovation, Jones (2001) examines new ideas, Powelon (2005)[1] stresses the effect of institutions, etc. The second question has been discussed by Pomeranz (2001) in his well-known study, *The Great Divergence*, where he suggests that external conditions, such as the exploitation of the New World, had been a major contributor to the Divergence between England and the Yangzi Delta. Without favorable outside conditions, England might have not distinguished itself as the first industrialized country. In a more recent work, Voigtlander and Voth (2006) argue that it is reasonable for England to have been the first to transition from a Malthusian state to that of modern growth because England had better initial conditions (i.e., it was richer and better urbanized) than China. In this paper, by modeling the contemporary economic characteristics of Britain and China's Yangzi Delta during 1400-1850, we conclude that differences in the social culture between Britain and China during that time underlay — and were sufficient to cause — the initial differences in both living standards and urbanized levels, as stressed by Voigtlander and Voth. In turn, these differences resulted in further gaps in physical capital accumulation, human capital accumulation, technology progress, and finally, the Great Divergence. We also claim that even with the resources and markets of the New World, due to China's particular culture, it would still have been impossible for China to develop an Industrial Revolution earlier than England. This point is consistent with that of Voigtlander and Voth (2006).

To avoid the proverbial fallacy of the blind men and the elephant, we study the combined effects of multiple factors in one unified model. That is, the contributions of four factors, namely, the reformation of the social culture, exploitation of the New World, expansion of trade, and development of technology, are unified to form a systematic description of the evolution of the Great Divergence. We will not include institutions in our model. This does not mean we look down upon the effect of institutions; rather, on one hand, we have not find a good way to model institutions in our framework, and on the other hand, we prefer to regard institutions as a long-run implication of a social culture, and thus crudely subsume them within 'culture'.

Our strategy is to employ a simple two-sector model, based on Stokey (2001), which compares Eastern and Western economic conditions that prevailed before the Industrial Revolution, and aims to find the internal

[1]Powelson, John P. (2005), A History of Wealth and Poverty: Why a Few Nations are Rich and Many Poor, Copyright© 1994 by the University of Michigan. All rights reserved. First published in the USA by the University of Michigan Press, 1994. Published on the World Wide Web by The Quaker Economist with permission from the University of Michigan Press, 2005.

mechanism that triggered modern growth. First, a benchmark is established to model the real conditions of the two economies that were very similar initially, i.e., during the 15^{th} century. The second step is to compare the effects of factors in different combinations on economic development. Some assumptions are made for convenience in a comparison of these factors. The subsequent step is to model the two different evolutions of Eastern-Western economies by two similar models but with very important differences in the social and cultural environment.

One challenge for us is to model and measure culture. Considerable research has been undertaken on culture and its effect on long-run economic development. There is now almost no doubt that the social and cultural environment has a great effect on individual preferences and, in turn, on societal choices with regard to political institutions and economic systems. However, how culture works and how culture and its effects are to be measured are still open questions. Existing research usually uses data on cultural establishments, cultural investments, cultural activities, etc., to measure culture.[2] However, according to the definition of Williams (1998),

"Culture is a state or process of human perfection, in terms of certain absolute or universal values. The analysis of culture, if such a definition is accepted, is essentially the discovery and description, in lives and works, of those values that can be seen to compose a timeless order, or to have permanent reference to the universal human condition."

Clearly, the existing methods of measurement have not been effective. Since quantitative analysis differs from qualitative analysis, it is possible that some concrete cultural trait may differ very much between two countries, and thus have different, even opposite, effects on economic development, while the two countries may yet share the same quantitative cultural characteristics. Thus, since we are concerned much more about a concrete cultural trait[3] and its effect on the economy, a very special method of measuring culture is necessary, and we also need to develop a very special model to study the operational mechanism of the culture.

The rest of the paper is structured as follows. In Section 2, we establish our benchmark framework to develop some basic conclusions; the framework is designed to be tractable enough to model the real economies of England and the Yangzi Delta region during 1400-1850. In the third sec-

[2]Jasna Horvat, Sanda Katavi, Martina Mikrut, and Irena Ograjenšek (2003), Conceptualising and Measuring Culture in Surveys: Case Study in the Republic of Croatia, Developments in Applied Statistics, Anuška Ferligoj and Andrej Mrvar (Editors) Metodološki zvezki, 19, Ljubljana: FDV, 2003.

[3]Culture as an aggregate concept has many different concrete traits, or different aspects, where each trait can have different and even opposite effects on economic development. Thus, when we carry out research on culture, we are in fact usually concerning only a part of the traits or aspects.

tion, we describe the different social cultures of East and West and develop our model to study and explain the process of the Divergence. Then, in Section 4, we present evidence that supports our explanation. Finally, we summarize our conclusions in Section 5.

2. THE MODEL

To begin, we consider two economies both having a system of private ownership. They are designed to model the real economies of England and the Yangzi Delta during 1400-1850. This was a time when agriculture and handicraft industries coexisted for both economies. During this time, the industries that developed in these two economies were initially very similar; subsequently, the two economies began to differentiate. From then on, England gradually industrialized, while the Yangzi Delta in China developed increasingly along a labor-intensive path. In fact, at the beginning of this period, there were almost no differences between the two economies except in terms of the cultural environment and social institutions (see Ken Pomeranz's The Great Divergence). Thus, for the purpose of highlighting the formative processes that led to the Divergence, we establish models of the two similar economies with the same parameters excepting for the cultural difference. Then, as the model evolves, this unique parameter should cause the economies to become quite different from each other. In this way, the factor in question (namely, culture) and its effects will be prominent.

2.1. The Benchmark Model

In this section, we develop a benchmark model which in the following section can effectively explain both Western and Eastern economies.

We assume a model in which there are many similar families, each participating in both agriculture and industry. The aggregate economic population, N, is distributed in two sectors: agricultural labor, N_a, and manufacturing (industrial) labor, N_m. We define n_a and n_m as the labor shares of the respective sectors. Then, we have:

$$n_a + n_m = 1. \tag{1}$$

Agricultural Production. For the agricultural sector, we include the input factors of (i) the land per capita, $l_a \equiv L_a/N$, where L_a is the aggregate land available in the economy and is assumed fixed and (ii) labor with share n_a. The per-capita agricultural output is given by Y_a in constant-return technology. That is,

$$Y_a = B(L_a)^{\beta}(n_a N)^{1-\beta}. \tag{2}$$

In Eq. (2), B represents the general level of societal agricultural technology, which is assumed to be the farming production technology. We take the agricultural technological progress to be in phase with the industrial technological progress, A, as a result of which B/A is always a constant, ξ. For simplicity, we will assume $\xi = 1$ and denote agricultural production throughout this paper by the adjusted per-capita productivity.

$$y_a = (l_a)^{\beta} n_a^{1-\beta} \tag{2'}$$

Markets of both agricultural products and labor are assumed to be competitive; thus, the price and wage are given for all agents in the economy. Since members are free to work in either agriculture or manufacturing, the two sectors will have an equal wage.

Industrial Production.[4] In the manufacturing sector, we model production and technological progress by following the approach of Aghion and Howitt (1992, 1998), which is consistent with the work of Ha (2002). A single final output is produced in a competitive market by input factors that include human capital and a continuum of intermediate products in accordance with the function:

$$Y = (n_m N)^{1-\alpha} \int_0^1 A_i x_i^{\alpha} di. \tag{3}$$

In Eq. (3), x_i is the output flow of intermediate product i and A_i is the productivity parameter of intermediate product i. Intermediate products are produced by innovative monopolistic firms with technologies; thus, $x_i = k_i/A_i$ for intermediate product i. The firm's profit is $\pi_i = p_i x_i - r k_i$, where r is the rental rate of capital and the equilibrium price, p_i, of intermediate good i is just its marginal product, i.e., $p_i = (n_m N)^{1-\alpha} A_i \alpha x_i^{\alpha-1}$. The maximized flow of profit is given as $\pi_i = (1-\alpha)(n_m h)^{1-\alpha} A_i \alpha x_i^{\alpha}$. Defining A more precisely as the average productivity and K as the total capital,

[4]Questions may be raised for this and next section concerning whether our approach of modeling industrial production by using intermediate production and technology progress by R&D innovation is reasonable for a historical period, namely, the 15^{th} century. In response, we argue that initially there was undoubtedly a very low level of industrialization in both Europe and China, and almost no pure R&D occurred. However, that does not mean we should not use a model that is suitable for studying modern economic development and the mechanism of technological progress to study and discover why the Industrial Revolution did not happen before the 18^{th} century. Second, if we want to know why technological development was so slow at that time and then rather abruptly began to grow at a rapid pace, we need to know what conditions were not met initially and what happened subsequently. However, an agricultural economic model may never yield us the right answer. Thirdly, from the viewpoint of unified theory, we need models that can consistently address questions.

we have

$$A = \int_0^1 A_i di \text{ and } K = \int_0^1 A_i x_i di.$$

At equilibrium, all intermediate firms produce equal amounts of product, x. Then, we obtain:

$$r = \alpha^2 (K/An_m N)^{\alpha-1}. \tag{4}$$

The profit and the aggregate production function are now simply $\prod_m = \alpha(1-\alpha)K^\alpha (An_m N)^{1-\alpha}$ and $Y_m = (n_m N)^{1-\alpha} \int_0^1 A_i x_i^\alpha di = K^\alpha (An_m N)^{1-\alpha}$ or, in per-capita productivity-adjusted notation,

$$\pi_m = \alpha(1-\alpha)k^\alpha (n_m)^{1-\alpha} \text{ and } y_m = k^\alpha (n_m)^{1-\alpha}. \tag{5}$$

Innovation. The intermediate producer has the motivation to innovate for increasing productivity. Innovations follow a Poisson process with an arrival rate of λn; so, the growth rate of A is $\dot{A}/A = \lambda n \equiv g$, where λ is the productivity parameter for R&D, n is the research intensity that is adjusted by the productivity level, viz., the ratio of the R&D expenditure, G, to A.

The value of an innovation is determined by the asset pricing equation:

$$rV = \pi_m - \lambda n V. \tag{6}$$

In Eq. (6), V is the value of the innovation. This implies that the expected income of the innovation, rV, is equal to the profit flow of an intermediate production under the new technology less the expected loss of capital when the monopolist is replaced by the next innovator with a probability of λn. From (6), we get:

$$V = \frac{\pi_m}{r + \lambda n} \tag{7}$$

Following the approach of Howitt (1999, 2000), the optimal level of R&D is determined by the arbitrage condition, namely, the marginal cost of an extra unit of R&D equals the marginal expected benefit. If research expenditures are subsidized at a proportional rate, Ψ, the marginal cost of raising the research intensity by one unit is $d(1-\Psi)G/dn = (1-\Psi)A$, whereas the marginal expected benefit is λV. Thus, we have:

$$1 - \Psi = \lambda \frac{\tilde{\pi}}{r + \lambda n}, \tag{8}$$

where $\tilde{\pi} = \pi/A$. By ruling out negative R&D, we obtain the following from Eqs. (4), (5), and (8).

$$\begin{aligned} g &= \lambda n = \max\left\{0, \frac{\tilde{\pi}_m}{1-\Psi} - r\right\} \\ &= \max\left\{0, \alpha(\frac{k}{n_m})^{\alpha-1}(\frac{\lambda(1-\alpha)}{1-\Psi}k - \alpha)\right\}. \end{aligned} \tag{9}$$

Eq. (9) shows there is a threshold level $k < \tilde{k}$, where $\tilde{k} = \alpha(1-\Psi)/[\lambda(1-\alpha)]$, below which no R&D takes place. Thus, we have our first proposition.

PROPOSITION 1. *R&D takes place only when* $k > \tilde{k}$.[5]

Trade. Agricultural products are assumed to be perishable and a surplus is undesirable. In the case of insufficient supply, additional quantities can be obtained by trading industrial product. (On the eve of the Industrial Revolution, a high population density created heavy survival pressures, which are regarded as the initial force behind the development of industry.)

The per-capita farming consumption and the importation of farming produce are defined to be c_a and i_a, respectively, and are related to the farming production defined above by:

$$c_a = y_a + i_a. \tag{10}$$

Following the argument of Stokey (2002), trade is assumed to be welfare-increasing at the margin. This means that foreign products may be cheaper than the same goods that are produced at home; thus, it costs less to export products in exchange for imports. For simplicity, we continue using Stokey's method and assume throughout this paper that there is a fixed parameter, $\tau \in [0, 1]$, where

$$x_m = (1-\tau)i_a. \tag{11}$$

Preference. We further assume there is an infinite-lived representative family or individual in the model economies, which always seeks to optimize its number of children as in Galor (2002, 2004) and Lucas (1998). However, in our model, we can optimize the population growth-rate instead of the number of children. This makes no essential difference in actual fact. For simplicity, and also given that the population growth-rate does not change significantly except over long periods of time, for this parameter we will first use a fixed value that corresponds to the actual population growth-rate during 1400-1850, and then we will relax this constraint as necessary.

[5]This is a part of Proposition 1 in Ha (2002).

One important difference in our treatment of the Divergence problem is that we include the physical capital in our preference function. This idea is not new in actual fact. Recently, Cole et al. (1992), Bakshi and Chen (1996), and Zou (1994, 1995, and 1998) and many others have applied this idea to various questions. It reflects the thought of Max Weber (1958): individuals accumulate wealth not only for consumption, but also for its own sake. Here, we employ the technique to convey the spirit of capitalism or mercantilism (we will further discuss in Section 3). Thus, we define the preference function as $u(c_a, c_m, k)$. This definition means that all three factors, i.e., farming consumption, c_a, industrial consumption, c_m, and physical capital, k, influence individual preferences. Furthermore, another key feature of the preference function that we want to capture follows Stokey (2002): individuals consume only agricultural goods up to a certain consumption threshold, $\tilde{c_a}$; hence, at low levels of income nothing but food is consumed. In particular, we assume the utility function,

$$u(c_a, c_m, k) = \begin{cases} c_a - \tilde{c_a}, & \text{if } c_a < \tilde{c_a} \\ \ln c_a + T_1 \ln c_m + T_2 \ln k, & \text{if } c_a \geq \tilde{c_a} \end{cases} \tag{12}$$

where T_1 is the rate of marginal utility between industrial and farming consumption and reflects the strength of the individual's preference for luxury, while T_2 is the rate of marginal utility between capital and consumption and reflects the strength of the society's mercantilism (or in Weber's words, the capitalist spirit).

Budget constraint. The household meets an international budget constraint,

$$\dot{k} = y - x_m + i_a - (\delta + \nu + g)k - c_m - c_a - g/\lambda, \tag{13}$$

where the aggregate income, $y = rk + wn_m + \pi_m + wn_a + r_l l_a$, is composed of the saving income, rk, the labor income, $w(n_a + n_m)$, the industrial profit, π_m, and the land rent income, $r_l l_a$, for the rent, r_l. The depreciation rate of physical capital is δ, ν is the population growth-rate, and x_m is the industrial production that is used to trade for the farmed quantity of product, i_a. As per the earlier definition, $g/\lambda = n$ denotes the physical assets used in R&D.

Agricultural production has been assumed to be entirely competitive, which implies that both land and labor attain their marginal products. That is, $r_l = \beta l_a^{\beta-1} n_a^{1-\beta}$, $w = (1-\beta) l_a^{\beta} n_a^{-\beta}$, and $y_a = r_l l_a + w n_a$. By Eqs. (10-13), we obtain:

$$\dot{k} = rk + \pi_m + w(1-\tau n_a) + (1-\tau) r_l l_a - (\delta + \nu + g)k - c_m - (1-\tau)c_a - g/\lambda. \tag{14}$$

2.2. Dynamic Optimization of the Household

Household behavior in the economy is divided into two parts: to work and to consume and invest. We consider them as two independent activities. For the former, the family needs to decide how much labor to put into agricultural production and how much into manufacturing. As we have discussed above, the choice makes the wages between the two sectors equal, which implies:

$$w = (1-\beta) l_a^{\beta} n_a^{-\beta} = (1-\alpha) k^{\alpha} n_m^{-\alpha}. \tag{15}$$

The relationship determines the share of labor in agriculture and manufacturing for a given land and capital accumulation. For the latter part of the household's decision, the family needs to choose consumption and savings to maximize its dynastic utility, subject to a budget constraint. The representative household optimizes its lifetime utilization by maximizing

$$\int_0^{\infty} e^{-\rho t} u(c_a, c_m, k) dt$$

subject to Eq. (13) and the initial conditions. However, we are interested in only the phase where $c_a \geq \tilde{c}_a$; this is also in line with Stokey's approach. In that regime, the optimal problem of the family is as follows.

$$\max_{\{k, c_a, c_m\}} \int_0^{\infty} e^{-\rho t} (\ln c_a + T_1 \ln c_m + T_2 \ln k) dt$$

subject to

$$\dot{k} = rk + \pi_m + w(1-\tau n_a) + (1-\tau) r_l l_a - (\delta + \nu + g)k - c_m - (1-\tau)c_a - g/\lambda \tag{14'}$$

Optimal conditions. It is easy to derive the following conditions.

$$c_a^{-1} - (1-\tau)\lambda_1 = 0. \tag{16}$$

$$T_1 c_m^{-1} - \lambda_1 = 0. \tag{17}$$

$$\dot{\lambda} = -T_2 k^{-1} + \lambda_1 (\rho - r + (\delta + \nu + g)). \tag{18}$$

In the above, λ_1 is the Hamiltonian multiplier. From Eqs. (16)-(18), we get the following Euler equation,

$$\frac{\dot{c}_m}{c_m} = r - (\delta + \nu + \rho + g) + T_2 T_1^{-1} \frac{c_m}{k}, \tag{19}$$

or the Ramsey rule of optimal saving by using (4),

$$\frac{\dot{c}_m}{c_m} = \alpha^2 (\frac{n_m}{k})^{1-\alpha} - (\delta + \nu + \rho + g) + T_2 T_1^{-1} \frac{c_m}{k}. \tag{19'}$$

From Eqs. (16-17), we get:

$$c_m = (1-\tau)T_1 c_a. \tag{20}$$

From Eq. (14') and the facts that $y_m = rk + \pi_m + wn_m$ and $y_a = r_l l_a + wn_a$, we get:

$$\dot{k} = k^\alpha n_m^{1-\alpha} - (\delta + \nu + g)k - c_m - g/\lambda + (1-\tau)(y_a - c_a). \tag{21}$$

Then, from Eq. (15), we find:

$$\frac{\dot{w}}{w} = \alpha(\frac{\dot{k}}{k} - \frac{\dot{n}_m}{n_m}) = \beta(\frac{\dot{l}_a}{l_a} - \frac{\dot{n}_a}{n_a}). \tag{22}$$

Noting that $n_m = 1 - n_a$ and $l_a \equiv l_0 e^{-(\nu+g)t}$ imply $\frac{\dot{n}_m}{n_m} = -\frac{n_a}{1-n_a}\frac{\dot{n}_a}{n_a}$ and $\frac{\dot{l}_a}{l_a} = -(\nu+g)$, we obtain from Eq. (22) the following.

$$\alpha\frac{\dot{k}}{k} + (\beta + \alpha\frac{n_a}{1-n_a})\frac{\dot{n}_a}{n_a} + \nu + g = 0. \tag{23}$$

Steady state equilibrium. The dynamics of the basic model are described by Eqs. (19'), (21) and (23). At steady state, the variables are constant; thus, $\dot{k} = \dot{c} = \dot{n}_a = 0$. These three equations then yield:

$$0 = \alpha^2(\frac{n_m}{k})^{1-\alpha} - (\delta + \nu + \rho + g) + T_2 T_1^{-1}\frac{c_m}{k} \tag{24}$$

$$0 = k^\alpha n_m^{1-\alpha} - (\delta + \nu + g)k - c_m - g/\lambda + (1-\tau)(y_a - c_a) \tag{25}$$

$$\nu + g = 0. \tag{26}$$

Using Eq. (15), we have the following.

$$k = s\left(\frac{l_a}{n_a}\right)^{\beta/\alpha}(1-n_a) \equiv k(l_a, n_a). \tag{27}$$

In Eq. (27), $s \equiv \left(\frac{(1-\beta)}{1-\alpha}\right)^{1/\alpha}$.

Substituting (27) for k in (24) and solving for c_m yields:

$$c_m = \frac{T_1}{T_2}[\delta + \rho - r(l_a, n_a)]k(l_a, n_a). \tag{28}$$

In Eq. (28), $r(l_a, n_a) \equiv \alpha^2(\frac{1-n_a}{k(l_a,n_a)})^{1-\alpha}$.

Then, by combining Eqs. (27) and (28) with Eq. (25), we obtain the following equation that is expressed in n_a.

$$\begin{aligned} 0 &= k(l_a, n_a)^{\alpha}(1-n_a)^{1-\alpha} - (\delta+\nu+g)k(l_a, n_a) \\ &- c_m(l_a, n_a) - g/\lambda + (1-\tau)(y_a(l_a, n_a) - c_a(l_a, n_a)). \end{aligned} \tag{29}$$

At steady state, by Eq. (26), $\nu + g$ is zero, which implies that l_a is constant; thus, by Eq. (29), n_a is also constant. Then, the steady-state capital, k^*, manufacturing consumption, c_m^*, and agricultural consumption, c_a^*, are given by Eqs. (27), (28), and (20), respectively. At last, from Eq. (9), we obtain the equilibrium technological growth rate,

$$g^* = \max\left\{0, \alpha(\frac{k^*}{1-n_a^*})^{\alpha-1}(\frac{\lambda(1-\alpha)}{1-\Psi}k^* - \alpha)\right\}. \tag{30}$$

From Proposition 1 and Eq. (26), we have:

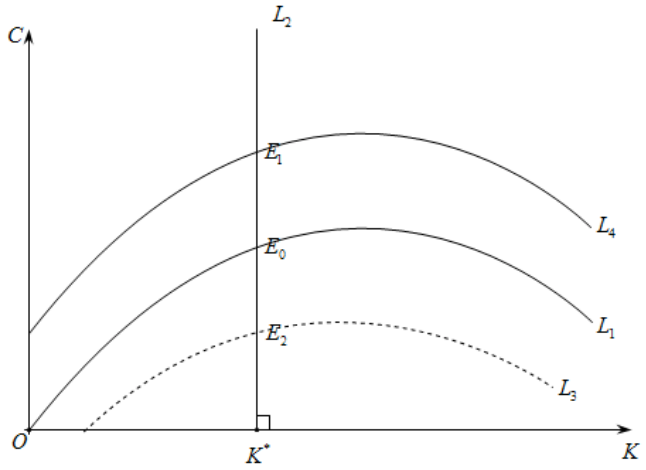
PROPOSITION 2. $g^* = \begin{cases} > 0 & \textit{when } k^* > \tilde{k} \\ = 0 & \textit{when } k^* \leq \tilde{k} \end{cases}$, *while* $\nu^* = \begin{cases} < 0 & \textit{when } k^* > \tilde{k} \\ = 0 & \textit{when } k^* \leq \tilde{k} \end{cases}$.

This proposition says that when capital accumulation is comparatively low, technological progress and population growth are almost zero. This is a very good explanation of a Malthusian economy. When capital accumulation reaches a comparatively high level, technological progress advances; however, population growth is reduced. This corresponds exactly to what happened in Western economies during the second phase of the Industrial Revolution.

Dynamic Analysis of the Basic Model. First, we consider the case where the division of labor between manufacturing and agriculture is fixed. When $T_2 = 0$, Eq. (19') reduces to the optimal savings equation of the Ramsey model. The dynamics of the system are roughly shown in Figure 1, where we plot consumption vs. capital. The vertical line, L2, is where $\dot{c} = 0$. For the thick curved line, L1, $\dot{k} = 0$. E0 is the Ramsey equilibrium, which is stable in the long run. Any shocks, such as an increase in consumption demand, capital accumulation, a natural disaster, etc., will have only an effect on the level, but no long-term effect on growth. Some shocks may put L2 to the right, thereby increasing the equilibrium level of capital accumulation but no shock can move L2 past the golden-rule point. This is commonly discussed in textbooks and we assume it is familiar to the reader.

In comparison, when $T_2 \neq 0$, the consumption-balance line, $\dot{c} = 0$, becomes a parabola, which is shown by the dotted line in Figure 2. This figure also shows that the new equilibrium, E3, jumps from k^* to k^{**}.

FIG. 1. Traditional Ramsey Equilibrium with $T_2 = 0$



As before, the horizontal axis denotes the capital, the vertical axis denotes the consumption, and the solid upright line is the original line, L2, from Figure 1. The solid curved line is again $\dot{k} = 0$, and E0 is the original Ramsey equilibrium. The equilibrium, E3, is greatly different from the Ramsey equilibrium in that the equilibrium level of capital accumulation has now jumped past the golden-rule point.

Let us now examine this difference through a more formal approach. From Eqs. (15) and (24)—(26) and by assuming $c_a = \tilde{c}_a$, we get:

$$k^{\alpha} n_m^{1-\alpha} = s_1 k + s_2. \tag{31}$$

In Eq. (31), $s_1 \equiv \frac{(\delta+\rho)+\delta T_2/T_1}{\alpha^2+T_2/T_1}$, and $s_2 \equiv \frac{T_2/T_1}{\alpha^2+T_2/T_1}[g/\lambda + (1-\tau)(\tilde{c}_a - y_a)]$.

Equation (31) implies that for any specific n_a and n_m, the equilibrium level of capital is determined by two functions, $q = k^{\alpha} n_m^{1-\alpha}$ and $q = s_1 k + s_2$. These are shown in Figure 3 by l_3 and l_1, respectively, and there are two equilibrium points, e_1 and e_2, which correspond to the two levels of capital, k_1 and k_2. While e_1 is not stable, e_2 is stable.

From the definitions of s_1 and s_2, it is easy to derive

$$\frac{ds_1}{dT_2} = -\frac{[(1-\alpha^2)\delta + \rho]}{(\alpha^2 + T_2/T_1)^2} \frac{1}{T_1} < 0$$

and $\frac{ds_2}{dT_2} = \frac{\alpha^2}{(\alpha^2+T_2/T_1)^2} \frac{1}{T_1}[g/\lambda + (1-\tau)(\tilde{c}_a - y_a)] > 0$. The above relationships imply that when T_2 is increased, b_1 in Figure 3 rises to b_2, while the slope of the line l_1 increases to that of the line l_2. From the figure, it can be seen

FIG. 2. Equilibrium in our model with $T_2 \neq 0$

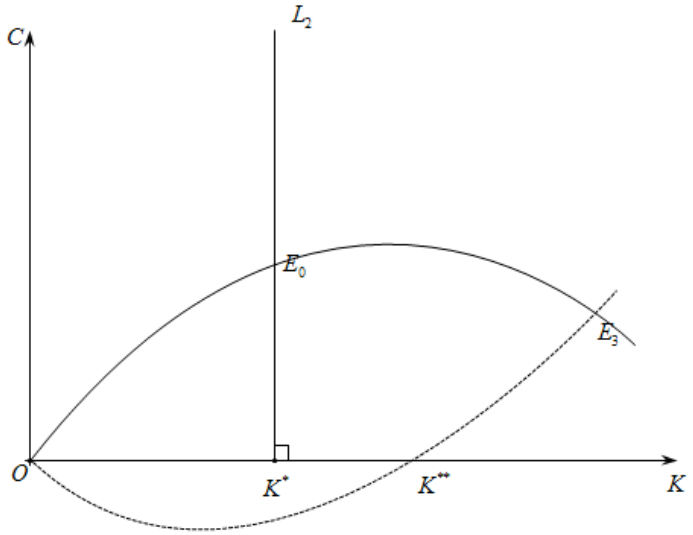
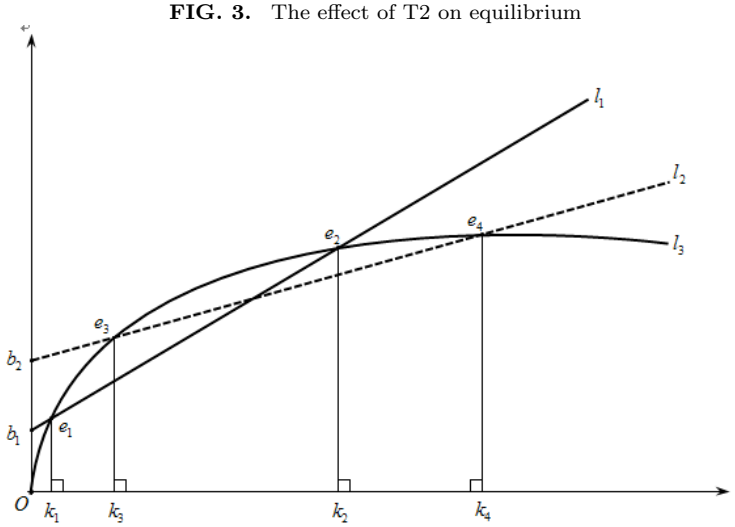


FIG. 3. The effect of T2 on equilibrium



that both equilibrium levels of capital are increased but the higher level increases more.

All the above taken together imply that an economy with an initial capital level that is greater than the low equilibrium point will converge to a higher equilibrium, while one with an initial capital that is below the low

equilibrium point increasingly approaches the zero-capital-accumulation equilibrium. The stronger the accumulation of the capitalist spirit in the economy is, the higher the level of capital at the nontrivial equilibrium will be.

Rigorously, we establish the following result, the proof of which is given in Appendix A.

PROPOSITION 3. *When the initial equilibrium level of capital is comparatively low, i.e.,* $k^* < \tilde{k}$*, if the labor cost of agricultural production* $w_a \equiv (1-\beta)(\frac{l_a}{n_a})^{\beta}$ *satisfies*

$$w_a > \frac{1-\alpha}{1-\tau}\left(\frac{T_2}{T_1}\frac{\alpha}{\delta+\rho}\right)^{\alpha/(1-\alpha)}, \tag{32}$$

then $\frac{dk^*}{dT_2} > 0$*; otherwise,* $\frac{dk^*}{dT_2} \leq 0$.

Proposition 3 states that when the existing level of capital is comparatively low, the stronger the capitalist spirit in a country, the greater will be its equilibrium level of capital, as long as the marginal product of agricultural labor is sufficiently high.

Now, we consider the case when the labor distribution is not fixed. This means we now must consider the dynamic contribution of Eq. (23) to the system. From the analysis above, we see there are always two equilibria: one high and the other low. The problem is how to transition from the low equilibrium to the high equilibrium. Eq. (23) implies that if each term in the left is non-negative, then the only possible solution is a trivial one. Thus, to achieve growth in capital (or productivity), it is necessary for at least one other term to be negative. Then, the population decrease might be one possible explanation for the modern growth that results from war or natural disasters, for example, but it cannot generate a sufficiently negative term. The only remaining possibility is a decrease in the share of agricultural labor. This is consistent with the conclusions of Proposition 3. The implication is that industrialization pushes an economy toward a high equilibrium, while agricultural-based economies converge to the low equilibrium. We will further discuss the details of the development from a Malthusian state to a stage of modern growth in the following sections.

The model is developed to be tractable enough to give prominence to cultural and systemic differences in the real economic conditions of Britain and China during the period of interest. In next section, we will introduce different cultural environments to the two economies and analyze their respective evolutions. Then, we will also fit the basic model to Eastern and Western economies in section 3.

3. THE GREAT DIVERGENCE

The basic model we have developed in the last section does not directly match either of the two economies. In this section, we will focus on the differences between them and modify the basic model to fit each of them.

3.1. Differences between East and West and Assumptions

Before the Renaissance, people in both Europe and China lived in a society that conformed to the feudal structure of the Middle Ages, where land belonged to the nobles in Europe (landholders in China). Peasants rented the land from the nobles (or landholders), and worked from sunrise to sundown but even the nobles (or landholders) had few creature comforts. However, during and after the Renaissance, several differences arose between East and West.

To be clear about how the differences transpired, we need to first learn the process and details of the Renaissance and its effect in Europe.

3.1.1. The Renaissance and its effect in Europe

In the late Middle Ages, the town populations increased in Europe because of the threat to country farmers of invasion from barbarians; people left the country for towns and cities so that they could engage in more profitable pursuits.[6] According to Smith's theory, social division and large, assembled, living populations are two main important preconditions for the development of capitalism. Thus, the accumulation of city populations was necessary for initial capitalistic economic development. However, one barrier to the assembled living of humans was the plague. In the 14^{th} century, plague devastated one half of the population of Europe. For a long time, plague's threat lingered over Europe. However, the terrible "Black Death" taught the Europeans the importance of healthy and enlightened living styles. An important consequence of the scourge was that the shackle of religion was shaken to its very core.

The reason is that in the late 15^{th} century, when the plague abated, populations swelled and trade and the economy prospered once again, which resulted in the formation of a new middle class. The new middle class had new interests, new ideas, and new lifestyles. As a result, humanist ideas recovered. Then, the printing press invented by Gutenberg (in 1445) together with reforms in literary language further advanced the development of humanism, which resulted in changes in each aspect of culture in Europe.

The cultural changes in Europe during the Renaissance were universal. Aside from changes in painting, music, and architecture that are usual-

[6] http://www.learner.org/interactives/renaissance/middleages.html [Oct,12, 2008].

ly introduced,[7] one more important aspect arose that can be clarified by an example. On October 31, 1517, a German churchman named Martin Luther changed Christianity, which included the church's practice of selling indulgences (people could pay for reducing the time for prayer) and "saying in the native language instead of in Latin so that the church's teachings would be more accessible to the people". This reform ignited the Protestant Reformation. Many people believed the church needed to change. Several new Christian religions were established. According to The Renaissance,[8]

"The secular humanist idea held that the church should not rule civic matters, but should guide only spiritual matters. The church disdained the accumulation of wealth and worldly goods, supported a strong but limited education, and believed that moral and ethical behavior was dictated by scripture. Humanists, however, believed that wealth enabled them to do fine, noble deeds, that good citizens needed a good, well-rounded education (such as that advocated by the Greeks and Romans), and that moral and ethical issues were related more to secular society than to spiritual concerns."

The effect of the Protestant Reformation was significant. First, according to the spirit of Protestantism, Protestants did not need to see the gaining of profit as a sin but instead had to feel happy in working hard to glorify God. As a result, business boomed in Protestant regions; on the contrary, it declined in Papist regions (Duan, 1994, pp. 91-94). Thus, from then on, the most influential lesson from European culture, 'The Protestant Ethic and the Spirit of Capitalism' — to quote the title of Weber's classic study — was increasingly advanced. Second, the Protestant Reformation greatly reduced the effect of the Holy See, limited the monarch's power, and in turn, advanced developments in democratic policies and individualism. After all, the Protestant Reformation encouraged free thinking and motivated new ideas and scientific research. Schools were built and thus laid the basis for Europe to increasingly achieve educational and scientific progress. As a result, Europe made a great contribution in scientific progress during the 17^{th} century. Many luminaries came into prominence at that time, such as Galileo Galilei, Francis Bacon, Rene Descartes, John Locke, Isaac Newton, Blaise Pascal, and Pierre de Fermat. Thus, it is said that the 17^{th} century was a time of talent or a time for scientific revolution.

In sum, the Renaissance and the Protestant Reformation laid the foundation for early mercantilism in Europe, ignited the scientific revolution

[7] More information can be found in Wilkins and Hartt (1994).

[8] http://www.learner.org/interactives/renaissance/printing_sub.html [Oct,13, 2008].

in the 17^{th} century, and also produced a great effect on politics, society, economy, literature, art, etc. In turn, these together paved the way for Europe's adoption of the industrial revolution.

3.1.2. China during the Ming dynasty

The Ming dynasty (1368-1644) in China is a time that closely corresponds to the European Renaissance. Feudal monarchy was intensified in the initial Ming era by the Emperor Zhu Yuanzhang. Born into a farming family, the emperor 'attached importance to farming and repressed commerce' and pushed a 'ban-sea' policy to avoid the intrusion of seafarers. This blocked the development of business to some extent, which formed an obvious contrast to the rise of mercantilism (or 'the Spirit of Capitalism' in Weber's words) in Europe.

Policies in China's history were not stable, at least not in the Ming era. During about 2130 years from 221 BC, which marked the onset of the Qin dynasty, to 1911 A.D, which marked the end of the last empire (which belonged to the Manchu or Qing dynasty), 331 reigns transpired, wherein each emperor's reign lasted 6.4 years on average. Each emperor could decide policies in accordance with his preferences; thus, the continuity of policy was very low in old feudal China. This situation was comparatively much better during the Ming era. In all, 17 reigns lasted during the Ming era. On average, each emperor held power for about 16 years. However, after the first two years, the position of emperor changed hands very frequency; the shortest reign lasted only one month.

The institutional and cultural environments in the Ming era were not beneficial to the freedom of expression, individualism, humanism, mercantilism, or the scientific spirit. Firstly, political systems, especially during the early Ming era, were extremely harsh and increasingly corrupt, becoming ineffective at the close. The first emperor, Zhu Yuanzhang, was called a killer by some people because too many people were killed during his time, including even generals, who followed him, and his kin. Sometimes, all the residents in a whole street were killed although only one resident had committed an offence. As a result, no one had the courage to express dissenting opinions. In such an extensively autocratic society, humanity was completely disregarded and individualism was totally suppressed. This situation had such a lasting effect on the people that during the Sheng Zong reign, wherein the emperor was infatuated with Taoism and did not assume his position for two decades, the country's administrative machinery still worked well. One Ming emperor, Zhu Youxiao, was good at carpentry

while another, Wu Zong, worked even in the restaurant business and the pork trade. Why did the populace not pull down the useless empires? A partial explanation is that freedom of thought and civil liberties had long been denied, as a result of which ideas did not emerge. A deeper reason lies in the culture.

Traditional Chinese culture that was based on Confucianism, Buddhism, and Taoism taught people ethical guidelines such as "the three cardinal guides and the five constant virtues",[9] "the three forms of obedience and the four virtues"[10], which prescribed that the people should absolutely obey, submit, and stick to the empire. As a result, people usually believed that to fight against either the empire or government officers was the greatest outrage and the worst offence. Thus, in such a cultural environment, individualism and a liberal spirit had no place; however, they constitute the most important base for producing innovation and scientific thought.

Other important lessons from Eastern traditional culture may be "the three religions and the nine academic schools",[11] and "the preservation of family lineage from generation to generation".[12] The former says that in ancient China, the first choice was for a son to become a sage, while to become, literally, an artificer or a businessman was usually considered the least desirable. This directly illustrates that the mercantile spirit was weak in traditional China and mirrors the tenet that prevailed in Europe prior to the Protestant Reformation. This explains why traditional Chinese did not attach as much importance to capital accumulation. Sons guaranteed their parents' well-being in their old age. The wide-spread mercantilism that arose in Europe in the 19^{th} century was in direct contrast to these Eastern values.

Actually, during the middle of the Ming era, especially during the reign of Zhu Di, policies were a little relaxed and culture and the economy obtained a chance to develop. This can be shown by two examples. The first is that

[9]The three cardinal guides: ruler guides subject; father guides son; and husband guides wife. The five constant virtues: benevolence; righteousness; propriety; wisdom; and fidelity.

[10]The three forms of obedience: to father before marriage; to husband after marriage; and to son after the death of the husband. The four virtues: morality; proper speech; modest manner; and diligent needlework.

[11]According to ancient tradition in China, people were divided into different classes according to their statuses and occupations. The three main religions were Confucianism, Buddhism, and Taoism. The nine academic schools usually ranked nine occupations in the following order: monarch; sage; hermit; government official; scholar; warrior; farmer; worker; and, lastly, the merchant.

[12]Many Chinese people even now believe the preservation of family lineage from generation to generation is very important. As a result, even today, people usually prefer to have boys than girls.

of Zheng He, a famous seafarer in Chinese history, who had navigated seven times to the Atlantic. Another is that the Yǒnglè Encyclopedia was commissioned by Emperor Yongle of the Chinese Ming dynasty in 1403. It is believed to be the world's largest known general encyclopedia, and one of the earliest. However, because the socio-cultural environment in the Ming era was not beneficial enough to innovation, scientific progress, and business development as in Europe, a gap between China and Europe in the fundamental reformation of societal institutions, scientific progress, and business development increasingly formed in the 17^{th} century. The result was that by the end of the 17^{th} century, Europe had finished the necessary preparation for entrance into the modern industrial revolution in every aspect, while China was still wandering in an obsolete, feudal cultural environment.

In summary, we believe that the initial difference in social culture (the Reformation in European culture was ignited by the Renaissance and the Protestant Reformation) resulted in early differences in several aspects: mercantilism; the scientific spirit; individualism; and humanism (which worked as bases on motivating institutional innovation toward the direction of modern and equal.) In turn, these differences developed increasingly into an obvious gap between the two regions in terms of the economy, politics, and the level of technological progress. At last, the Great Divergence transpired. In the next section, we will model the process to make clear the function in the process of each factor: the culture; the New World (to verify Pomeranz's conjecture); trade (Galor's theory); and technological progress (supported by many scholars).

3.2. Fundamental Assumptions of the Model

For convenience of exposition and for clarifying the questions, we need to make several fundamental assumptions before establishing our model. Of course, there were several other cultural differences between East and West. However, it is beyond the scope of this paper to discuss each of them in detail. Instead, we focus only on societal preferences for mercantilism, culture, trade (the New World), and technological process. First, we will assume that the difference in the preference for mercantilism between England and China was large enough. Then, we check what might happen in our model.

Assumption 1. *Western culture was more beneficial to mercantilism than Eastern culture.*

Or directly,

Assumption 1': Western economies had a stronger capitalist spirit than Eastern economies, i.e., $T_2^w > T_2^e$.

Now we introduce the second assumption. According to Pomeranz (2001), the two regions were similar in terms of economic development around 1400 BC.[13] For convenience in comparison and for making clear the internal mechanism of the subsequent divergence between the two economies, we will assume that initially there were two equal economies and both initially had comparatively lower levels of capital accumulation.

ASSUMPTION 2. *The two economies had equal and very low levels of initial capital, i.e.,* $k_0^w = k_0^e = k_0 < \tilde{k}$.

Pomeranz's study further suggests the indispensable importance of the New World's contribution to England's break from the Malthusian stage towards the stage of the modern industrial revolution. By and large, we believe this assertion of Pomeranz is correct. However, we are still not clear about how the outside conditions worked and to what extent they were important in the progress of humankind. For modeling the contribution in the process of industrialization in England, the following condition is a crux.

Condition 1: The New World, as a sudden and immense source of new productive land, helped England's economy satisfy condition (33) on the real wage.

All other conditions of the two economies are assumed to be the same as described by the basic model. Thus, the only difference between the two economies was that in assumptions 1 and 2 and condition 1. In the next section, we will describe the evolution of the Great Divergence on the basis of the above criteria.

3.3. The Great Divergence

Having laid the above foundation, in this section, we explain by our model the process of the occurrence and development of the Great Divergence between England and the Yangzi delta during 1400-1850. We treat the process in two steps: (i) the original capital accumulation (OCA) stage and (ii) the modern growth (MG) stage.

The OCA stage (before 19th century). Initially, at this stage, according to Assumption 2, the original level of capital was low in both economies. Thus, by Proposition 1 in subsection 3.1, there was initially

[13] Pomeranz reported that the consumption of some luxuries, such as tea and sugar, in the Yangzi delta in China at that time was even more than that in England.

no significant technological progress in either economy. This is in fact the same as the real case of technological development in the long course of human history prior to the Industrial Revolution during which both technological progress and productivity developed very slowly. This situation was unchanged until the end of the 18^{th} century (see Figure 5).

The case of a near-zero rate of technological progress is trivial in our model. As shown in Figure 1, the economy remained at a stable level. This was precisely the case of a Malthusian economy in human history.

During this stage, growth rates of production were very low because of the low levels of capital and near-zero technological progress, which, in turn, implied a low population growth-rate. Humankind had spent a long time in this economic state, and the economic thinking that prevailed before the Industrial Revolution held this state to be an everlasting phenomenon. However, something changed at the end of this stage.

Incidental events that triggered change. Two events happened in Europe in the 16^{th} century that were significant for the advancement of humankind. One was the Renaissance and the Protestant Reformation as we discussed in subsection 3.1.1, which had a great effect on developments in the economy, culture, politics, art, humanities, etc., and, in turn, paved the way for the scientific revolution in the 17^{th} century in Europe. This led to Europe's adoption of the industrial revolution in the 18^{th} and 19^{th} centuries. The other event was the discovery of the New World. These were two independent, coincidental events but a great change occurred as a result of their conjunction. The former event is usually believed to have motivated the capitalist spirit, while the latter event, according to Condition 1, allowed condition (33) to be met. Vide Proposition 2, the capitalist spirit, in turn, had a positive effect on capital accumulation. This made it possible for England to accumulate higher degrees of capital.

Divergence that occurred during the MG stage. Now, we consider the differences between the English and Yangzi Delta economies. As a result of Assumption 1', the capitalist spirit was stronger in Western economies than in Eastern economies, and by Proposition 2, the society that was the first to meet condition (33) would be the first to achieve a higher level of capital accumulation. If neither economy could meet condition (33), neither should have evolved beyond the Malthusian stage in which they had remained throughout the course of history. If condition (33) was met by both economies, because England had a stronger capitalist spirit, England should have attained a greater equilibrium capital accumulation, and in turn, its level of capital should have been first to exceed the thresh-

old level, , which was necessary for embarking upon modern growth. Thus, we have our first corollary.

COROLLARY 1. *With only the difference in Assumption 1' (all other conditions being equal), the Yangzi delta would never attain the MG stage before England.*

What remains to be clarified is how (33) could be met. Actually, there are two ways. From the definition of w_a, one is a decrease in the share of agricultural labor, n_a, and the other is an increase in the per-capita land. Both can increase the marginal product of agricultural labor. The former is reasonable and easily understood. As we all know, every country, when undertaking a process of industrialization, may experience a population transition from the agricultural to the industrial sectors[14]. With regard to the latter, when the New World was discovered and integrated with England's economy, the population density in England was reduced, and, the real effective per-capita land increased. In turn, the marginal product of labor in the agricultural sector became larger, which further enhanced the capitalist spirit and capital accumulation in England.

From the last section, we know that the development by an economy of a high equilibrium depends on whether its initial level of capital, k_0, is greater than k_1, as shown in Figure 3. If k_0 is less than k_1, the economy converges to the zero equilibrium. Without the New World, if the English economy had developed through the natural growth of both population and technological progress, it is unlikely that its effective per-capita level of capital would have exceeded k_1. Even if some positive productivity shock had occurred before England had accumulated enough capital, the level of capital might have easily returned to zero. However, with the influence of the New World, a sudden and great increase in the available land and natural resources made it possible for England to accumulate considerable capital in a short span of time. It is reasonable to assume that in that process, the amount of capital would have surpassed k_1.

Without a strong capitalist spirit, even with the help of the New World, the model economy would still remain a Malthusian economy. On the other hand, we have shown above that with only a strong capitalist spirit, it was also impossible for an economy to escape from the Malthusian state. By combining these observations together, we deduce the following.

[14]For example, in China, when the policy was relaxed in allowing labor liquidity in 1990, a huge labor transition occurred, and in turn, a sustainable stage of rapid growth beginning from then on has already been ongoing for nearly two decades.

COROLLARY 2. *Both the capitalist spirit and the New World were necessary but not individually sufficient for achieving modern growth. However, when combined, they were both necessary and sufficient.*

From the above, we know that England accumulated its capital to a level that was high enough for attaining modern growth, partly because of outside conditions and partly because of internal factors (its social and cultural environment). The Yangzi Delta would not have accumulated enough capital even with the help of outside conditions such as the New World, because its special social culture did not encourage a capitalist spirit.

The Modern Growth Stage. The main feature of the modern growth stage is that the growth rates of production, population, and technological progress are obviously larger than zero. According to Proposition 1, only when capital accumulation is more than $\tilde{k}$ can the growth rate of technological progress exceed zero. In the last section, we showed it was possible for England to accumulate a high level of capital. When its capital was high enough, its technological level began to grow at a positive rate.

According to Galor's development,[15] early in industrialization, physical capital is the only engine that drives growth, whereas, at later stages, either technological progress and/or human capital dominates. This is because at later times, technological progress and the accumulation of human capital begin to be cost-effective, whereas in the earlier periods, they are not. Many other papers have clarified how technological progress works in driving the modern growth process. From all of them, it is clear that technological progress is the main force behind modern industrial growth. Thus, we will not pursue this direction any further. Instead, we will turn now to focus on trade's contribution.

3.4. Trade

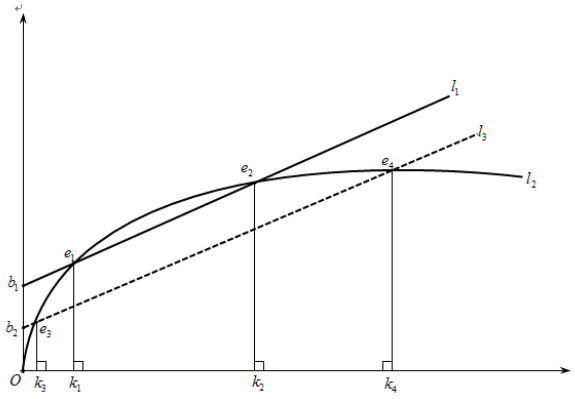
This section considers the effect of international trade on modern growth. From Eq. (10), $i_a = c_a - y_a$ denotes the food that an economy must import. In Eq. (32), the parameter s_2 becomes

$$s_2 = \frac{T_2/T_1}{\alpha^2 + T_2/T_1}[g/\lambda - (1-\tau)i_a], \tag{33}$$

[15] Galor and Moav (2004) and Galor (2005) believe that in the early stages of industrialization, physical capital accumulation is a primary source of economic growth. In the later stages of development, the return on human capital increases due to the capital-skill complementarity.

which implies that an increase in food importation will drive down line l_1 to line l_3, as shown in the following figure, viz., Figure 4. This, in turn, implies an increase in the high equilibrium level of capital accumulation for industrialized countries and a decrease in the already low equilibrium of agricultural-based regions.

FIG. 4. Trade's effect on equilibrium



We claim that trade has thus helped to enlarge the gap between industrial and agricultural economies. Trade has a two-sided effect. While trade further advances the development of advanced industrialized countries, it also thwarts industrialized development in underdeveloped countries and consigns these countries to progressively poorer labor-intensive economies. This conclusion is consistent with general theories of trade[16]; authors believe that international trade was important in initially promoting industrialized development in England. This also gives a better understanding of why the Qing (or Manchu) dynasty in China (which followed the Ming dynasty) had even attempted to carry out a closed-economy policy, but was thwarted by the Eight-Countries' Fire; perhaps, the Qing government had already been convinced of its bad effect, and naively sought to avoid it. Anyway, the real data in Table 1 clearly show that the levels of industrialization in countries such as China and India progressively worsened during the Industrial Revolution, while Western countries progressively advanced.

We can better understand trade by asking whether it is necessary for modern growth. Further, how much did this trade contribute to the Great Divergence? To focus on this kind of question, we consider in more detail

[16]For example, the conclusion is consistent with series studies on trade, such as Galor and Mountford (2006), Stocky (2001), and Romer (2002), in which international trade shapes the international distribution of labor.

a situation without trade. In this case, as shown by the line l_1 in Figure 4, there are still two equilibrium solutions. The one on the right, i.e., the higher level of capital, is stable, while the one on the left (a lower level of capital) is not. Thus, there are always two possibilities: to approach an economy with a stable and higher level of capital or to develop into an extremely poor state with zero capital. The outcome depends directly on the economy's initial level of capital, which, in turn, depends on the level of the economy's marginal product of labor, as we saw earlier.

There is an explanation for the evolution of an economy with a zero level of capital. Without trade, food can only be supplied by the agricultural production of each economy. Since there is no avenue for exchanging industrial production for agricultural product, trade is not present to motivate further industrial development. Without the motivation for industrial development, there is insufficient motivation for technological development. With limited arable land, the agricultural production in each economy can supply only a limited population. We illustrate this in the following manner.

$$
\begin{aligned}
&N \uparrow \\
&(1) \Rightarrow l_a \downarrow \\
&(2) \Rightarrow n_a \uparrow \\
&(3) \Rightarrow n_m \downarrow \\
&(4) \Rightarrow n_m = 0 \\
&(5) \Rightarrow N = \tilde{N}, c_a = \tilde{c}_a, c_m = y_m = k = 0.
\end{aligned}
$$

For an increasing population, N, in the first step, the per-capita land is reduced. In step (2), to keep the per-capita consumption of agricultural product greater than the minimum level, $\tilde{c}_a$, we must increase the agricultural labor share, n_a, which implies a decrease of the manufacturing labor share, n_m, in step (3). However, as shown in (4), eventually, n_m reaches zero and cannot be reduced further. Thus, the economy remains in a stable equilibrium in the long run, with the population being around a stable level, $\tilde{N}$, the per-capita consumption of agricultural product being $\tilde{c}_a$, and the per-capita capital, consumption, and industrial production being zero. This is just a Malthusian economy.

When there is no help from outside sources, the above process explains a long-term Malthusian economy either with or without trade. However, when external land and resources are available, the situation is different. An increase in the marginal product of labor in the agricultural sector

results in a surplus of agricultural labor. This implies a reversal of the arrows in steps (1), (2), and (3) of the above process. When the New World was discovered by Europe, the cultivated land effectively increased, thereby engendering just such a rise in the marginal product of labor. Hence, the manufacturing labor share was driven up and industry flourished. We see then that a higher equilibrium in terms of the level of capital may be attained even without trade. Considering these results, we have the following proposition.

PROPOSITION 4. *Trade is a supportive condition, but not a necessary condition for an economy to evolve towards modern growth. In particular, without trade and without the New World, the English economy would not have beaten a path towards modern growth.*

We can summarize our result as follows.[17]

Case 1: Absent a capitalist spirit, none of the steps in the progression to modern growth can happen.

Case 2: In the presence of a capitalist spirit but without an external source of land, again, none of the steps will occur.

Case 3: With both a capitalist spirit and an external land-source, an economy proceeds toward modern growth.

Case 4: With a capitalist spirit, an external land-source, and the addition of trade, industrializing economies benefit while agricultural economies lose.

We can now give a systematic explanation of the process that underlay the Great Divergence and modern growth.

3.5. A Unified Explanation and Some Evidence

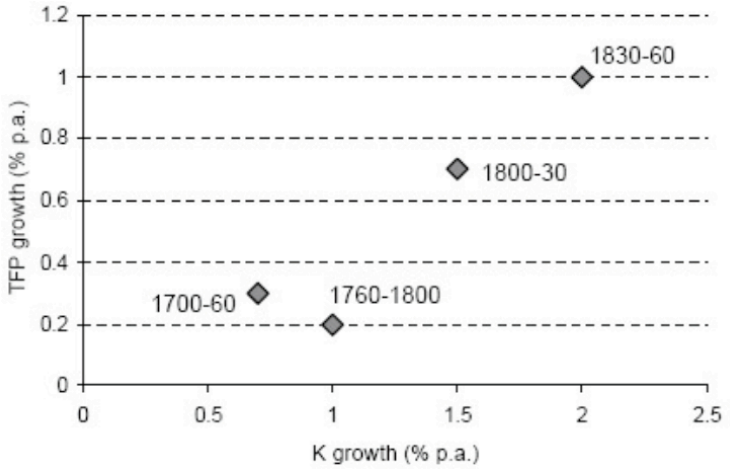
In the early stages of European history (i.e., before the Renaissance), the economy was in a state where individuals were constrained to only produce in the agricultural sector. Manufacturing and industry were relatively undeveloped. Most importantly, the cultural environment was not favorable to innovation, mercantilism, or the spirit of capitalism. As a result, capital accumulation stayed at a very low level, and the economies lingered in a long-term stable Malthusian equilibrium.[18] During that time, international trade was also undeveloped. One reasonable explanation for

[17] Here, because technological progress is in fact an intermediate variable but not an initial cause for modern growth, we have regarded it as one result of modern growth.

[18] "During a long reign of peace Heaven and Earth could not but propagate the human race, yet their resources that can be used to the support of mankind are limited. . . . Both Ch'ing [Qing] China and Tokugawa Japan ultimately came under this kind of Malthusian pressure, as did, earlier, England in the Later Middle Ages." Rostow (1973), p. 549.

this is that cost-effective transportation, such as rail and shipping, were all expensive and depended on high levels of capital accumulation.[19] Therefore, while capital accumulation remained insufficient, trade was not very effective, and in turn, industrial products could not be traded for necessary agricultural products. A lack of industrial development implied insufficient motivation for significant industrial technological development. The rate of technological progress was consequently low; this was also because technological development did depend on a high level of capital accumulation. (See Figure 5, which illustrates that before 1800, TFP growth in England was very low.)

FIG. 5. Annual growth rates of the TFP and aggregate capital of England. (Taken from Voigtlander and Voth, 2006).

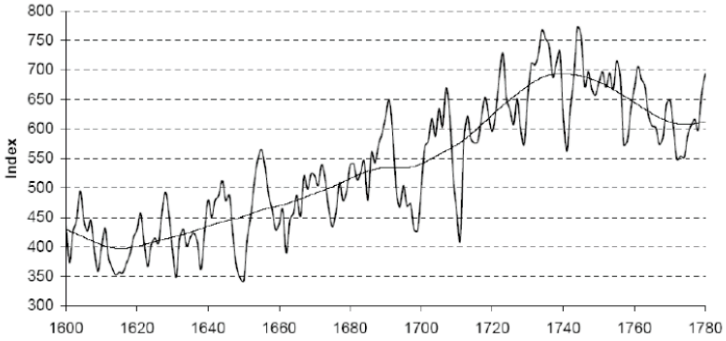


With the Renaissance in Europe, circumstances converged. The European Renaissance activated a mercantile and capitalistic spirit in society. The New World gave England the chance to meet condition (33) (as Figure 6 shows, the real wage in England greatly increased between 1620 and 1750).

England began to accumulate sufficient capital to transition to modern growth. Its capital accumulation reached a level that was high enough to establish infrastructures for trade, education, R&D, and many other social services. England then achieved positive growth in technological development, which enabled production in each sector to become sustainable and even more efficient. At the same time, trade conditions allowed it to import

[19] "The [lack of] increase in British trade is typical rather than extraordinary until the take-off in the last twenty years of the century (18) when . . . ". Rostow (1973), p. 549.

FIG. 6. Fluctuations in the real wage and the underlying trend for England. (Taken from Voigtlander and Voth, 2006.)



food from other countries more cheaply than to produce them domestically, which motivated further industrial development because industrial production was now more cost-effective. Thus, the presence of trade encouraged early industrial countries to industrialize further, while causing less developed countries to increasingly turn to agriculture. Figure 7 shows that there was a notable increase in industrial production that accompanied the growth of the main agricultural import, cotton. From Table 1, we see that industrialization in Western countries rose significantly, while it markedly decreased in Eastern countries, such as China and India.

FIG. 7. British industrial output and cotton imports, 1700-1913 (1913=100). Taken from Chapter 6 of Findlay and O'Rourke (2007).

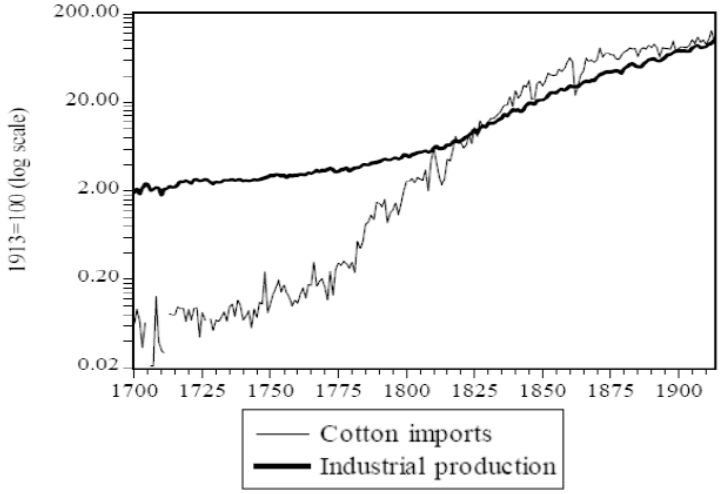


TABLE 1.

Per capita levels of industrialization, 1750-1913. Taken from Chapter 6 of Findlay and O'Rourke (2007).

(U.K. in 1900=100; 1913 boundaries)

Country	1750	1800	1860	1913
Austria-Hungary	7	7	11	32
Belgium	9	10	28	88
France	9	9	20	59
Germany	8	8	15	85
Italy	8	8	10	26
Russia	6	6	8	20
Spain	7	7	11	22
Sweden	7	8	15	67
Switzerland	7	10	26	87
United Kingdom	10	16	64	115
Canada	na	5	7	46
United States	4	9	21	126
Japan	7	7	7	20
China	8	6	4	3
India	7	6	3	2
Brazil	na	na	4	7
Mexico	na	na	5	7

4. RELATED RESEARCH

It has now become a widely accepted fact that cultural factors play an important role in the economic growth of any country. Many studies concerning the relationship of culture and economic growth have been conducted, such as Thompson (2001), Chang (1998), Harrison (1992) and Hofstede (1997, 2001).

Among the theories prevailing in the literature, for example, one theory has suggested that two developments in the early modern period were important to the Great Divergence and that both resulted from the introduction of movable type in Europe. The first development was the emergence of standardized written versions in vernacular languages that allowed information to be shared widely at low cost. The second was a series of revolutions, such as the rise of literacy within European societies, which shifted these sectors from a non-cooperative to a cooperative equilibrium. In any case, it is clear that the printing press was a crucial innovation in Renaissance Europe. However, because of the characteristics of the systems of writing, the introduction of movable type was less useful and therefore

slower to occur in the regions of Asia. Also, it is believed that the innovations that occurred in early Europe — technological, informational, financial, philosophical, etc. — were directly based on European cultural development. There also exists strong empirical evidence that economic development is associated with shifts away from absolute, traditional norms and values towards values that are increasingly rational, tolerant, trusting, and participative (Inglehart and Baker, 2000; Bell, 1973; Bell, 1976; Inglehart, 1988; Inglehart, 1997).

For Eastern societies as well, many studies demonstrate that the cultural environment affects economic development. The classical study is Weber's treatise, Confucianism and Taoism (1951). Weber argues that Confucianism created an environment that was hostile to capitalist development. Being a rational ethical system, it emphasized 'sib' or kinship as the social relationship of primary importance, and thereby promoted economically inefficient nepotism (Fukuyama, 2001).

One of the most recent studies that model the cultural effect is Kanatas and Stefanadis (2005). The authors stress that the link between a developed financial system and a high rate of economic growth may not be causal: the two may be driven by a third factor, namely, a country's culture. They believe culture can be the engine of economic prosperity and growth and a critical factor in the development of financial markets.

These theories furnish good support to our basic idea: culture does matter very much.

With regard to the second related aspect, mercantilism has long been believed to be significant to economic growth. For example, early studies by Schmoller (1897), Krishna (1924), and Heckscher (1935), and recent papers, such as McDermott (1999), stress the analysis of the effect of monopolistic rights on modern growth. This paper adds to the body of literature by adopting a model-based approach.

Thirdly, this paper is also related to the unified endogenous growth theory, as introduced in Section 1. Our work adds to this field of study inasmuch as we compose and systematically analyze four factors in one unified endogenous-growth model and develop some implications that are at variance with extant findings.

5. CONCLUSION

In this paper we have modeled the process of modern economic growth and the Great Divergence between Western and Eastern economies. Using only a simple model and classical economic analysis, we obtain many results

that match general modern economic conclusions. Through a series of analyses, we conclude the following.

Of course, the development of modern economic systems is a complex process that involves multiple influences. We demonstrate that the cultural environment was the most important and fundamental force behind it. However, social and cultural differences alone were not sufficient to cause the Great Divergence. Favorable outside circumstances, such as the exploitation of the New World, were also necessary for modern growth and for finally causing a divergence between countries in accordance with their social cultures.

Trade is an important supportive condition that enabled Western economies to enter the modern-growth phase, and at the same time, drove Eastern economies along an increasingly impoverished, agriculturally-dominant path.

Although technological progress was, of course, important to modern growth, in this paper we regarded it as a result or an intermediate effect of the endogenous-growth process.

We agree that institutions matter much for long-run economic growth. However, we regard institutions as a product of societal choice that is based on the unique cultural environment. This treatment of institutions might be construed as a flaw of this paper but we do not have any other good means of incorporating institutions into our model.

APPENDIX A

Proof of Proposition 3: Firstly, by (27), we get:

$$\frac{dk}{dn_a} = -s\left(\frac{l_a}{n_a}\right)^{\beta/\alpha}[1+\frac{\beta}{\alpha}(1-n_a)/n_a] < 0. \tag{A.1}$$

Then, by the assumption that $k^* < \tilde{k}$ and by using Proposition 1, we know that $g^* = 0$. Without technological progress, by Proposition 2, the population growth is also zero. Then, (24) and (25) become as follows.

$$0 = \alpha^2(\frac{n_m}{k})^{1-\alpha} - (\delta+\rho) + T_2T_1^{-1}\frac{c_m}{k}. \tag{A.2}$$

$$0 = k^\alpha n_m^{1-\alpha} - \delta k - c_m + (1-\tau)(y_a - c_a). \tag{A.3}$$

Equation (27) can be rewritten as $(1-\alpha)y_m/n_m = (1-\beta)y_a/n_a$. From this equation and also through (20), (A.3) becomes:

$$0 = (1+\tilde{t})(\frac{n_m}{k})^{1-\alpha} - \delta - (1+\frac{1}{T_1})\frac{c_m}{k}, \tag{A.4}$$

where $\tilde{t} \equiv (1-\tau)\frac{1-\alpha}{1-\beta}\frac{n_a}{n_m}$. Solving (A.2) and (A.4), we have:

$$\frac{c_m}{k} = \frac{(1+\tilde{t})(\delta+\rho)T_2/T_1 - \alpha\delta}{(1+\tilde{t})T_2/T_1 + \alpha(1+1/T_1)} \tag{A.5}$$

and

$$(\frac{n_m}{k})^{1-\alpha} = \frac{(1+1/T_1)(\delta+\rho) - \delta T_2/T_1}{(1+\tilde{t})T_2/T_1 + \alpha(1+1/T_1)}. \tag{A.6}$$

Again, using (27), we get $(\frac{k}{n_m})^{1-\alpha} = \left(\frac{(1-\beta)}{1-\alpha}\right)^{(1-\alpha)/\alpha}\left(\frac{l_a}{n_a}\right)^{\beta(1-\alpha)/\alpha}$. By substituting (27) into (A.6) and using the fact that $n_m = 1-n_a$, we get an equation for the share of agricultural labor, n_a. Differentiating the equation with respect to T_2, we have:

$$\frac{dn_a}{dT_2} = -(1+\frac{1}{T_1})\frac{1}{T_1}\frac{1}{\Delta}\left(\frac{\delta+\rho}{T_2/T_1}(\frac{1-\tau}{1-\alpha}w_a)^{(1-\alpha)/\alpha} - \alpha\right), \tag{A.7}$$

where

$$\Delta = \left(1+\frac{1-\alpha}{1-\beta}\frac{n_a}{n_m}\right)T_2(n_a)^{-\beta(1-\alpha)/\alpha} + \beta(1-\alpha)(1+\frac{1}{T_1})\frac{1}{n_a} + T_2\frac{1-\alpha}{1-\beta}n_m^{-2} > 0$$

and $w_a \equiv (1-\beta)(\frac{l_a}{n_a})^{\beta}$ as before, which is the marginal product of labor in the agricultural sector or the real wage of agricultural labor. From (A.7), it is clear that when $w_a > \frac{1-\alpha}{1-\tau}\left(\frac{T_2}{T_1}\frac{\alpha}{\delta+\rho}\right)^{\alpha/(1-\alpha)}$, the labor cost of agricultural production is larger than a fixed level and then, $\frac{dn_a}{dT_2} < 0$. Together with (A.1), we have completed the proof.

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