GeoPopulation-Institution Hypothesis: Reconciling American Development Process and Reversal of Fortune within a Unified Growth Framework

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4 September 2016

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ABSTRACT

We develop a unified growth theory for the Western Hemisphere during the colonization era. We posit a unified growth model with transatlantic migration and slavery trade to reconcile development in the Thirteen Colonies/United States during AD1700-AD1860. Then we apply the model across American regions/countries, and propose the GeoPopulation-Institution hypothesis to explain divergence: whenever its geographic or political environments relatively favored the buildup of Black slaves (or non-White forced labor), through slavery institution that disincentivized the Blacks to make improvements, a region/country was likely to suffer a reversal of fortune. Geography, population and institution are inseparable in understanding American economic history.

Keywords: GeoPopulation-Institution Hypothesis; American Economic History; Reversal of fortune; Unified Growth Theory; Transatlantic Migration and Slavery Trade

JEL Codes: E1, N1, O5

* I wish to thank Yulei Luo, Joseph S.K. Wu, Stephen Y.W. Chiu, Chenggang Xu, Chi-Wa Yuen, Paul S.H. Lau and Fang Yang for helpful discussions, as well as seminar participants at the University of Hong Kong 2016. Financial support from the Hong Kong PhD Fellowship Scheme (PF11-08043) and Sir Edward Youde Memorial Fellowships (for Postgraduate Research Students 2013/14) are gratefully acknowledged.

"We can send from here [West Indies] in the name of the Holy Trinity, all the slaves and brazilwood that can be sold." (Christopher Columbus 1498, 59)

"Free labor has the inspiration of hope; pure slavery has no hope." (Abraham Lincoln 1859, 160)

1 INTRODUCTION

We need a unified growth theory for the Western Hemisphere. This paper investigates how geography, population and institution fostered the evolution of European settlement, African slavery import and the standard of living in the New World economies during the colonization era.[1] The discovery of America by Christopher Columbus in AD1492 initiated the Atlantic European powers' (Spain, Portugal, England, France, and the Netherlands) exploration and colonization of the American continents. For the purpose of exploiting economic opportunities or spreading political and religious influences, these European powers either encouraged internal migration or traded African slaves to promote settlement in the American land. Due to the difference in legal status between European migrants and African slaves, the population structure constituted from these two sources had implications on economic progress. With this background, it is our central thesis to reconcile development and divergence (reversal of fortune) in the American continents during the colonization era within a unified growth framework.

Reversal of fortune refers to the reverse in relative per capita incomes between two locations. It can occur on two levels: within-country and across-countries. One within-country example took place in the United States. The southern part of the United States (hereafter US-South) was originally richer than the northern part (hereafter US-North); however, this situation had been reversed by AD1840. Lindert and Williamson (2013, 752) suggested that "the decline of frontier super-returns, institutional failure, or exceptionally severe damage incurred in the Revolutionary War" were possible reasons for the relative decline of US-South.

Reversal of fortune also occurred at country level. For example, Bolivia, Ecuador and Peru were once the most developed regions in America in AD1500. However, they are among the poorest countries in America today. On the other hand, the United States and Canada were the most underdeveloped areas in America in AD1500, but now they are among the richest countries in the world (Maddison 2008). There are two main hypotheses explaining countries' long-run economic development: the geography hypothesis and the institutions hypothesis. The geography hypothesis (Montesquieu 1899[1748]; Marshall 1895) emphasized the role of geographic factors, such as climate and resources, in affecting people's vigor and strength, and

[1] Colonization of America began with the arrival of Christopher Columbus in AD1492. American decolonization started with the American Revolution in AD1775. By AD1860 most American countries had gained independence from the European powers. In this paper, "colonization era" refers to the period AD1492-AD1860. Slavery was an important labor market institution characterizing this period. Christopher Columbus and Abraham Lincoln are two representative figures defining the opening and closing of slavery in America. See the quotes ahead of the Introduction.

hence the country's prosperity. However, since geographic factors are fixed over time, it seems that the geography hypothesis fails to account for the halfway relative income reverses in America. Acemoglu et al. (2001, 2002) favored the institutions hypothesis; in the American context settler mortality and/or initial prosperity of a newly colonized region would influence the type of institutions European powers introduced to it and hence its economic fortune. We argue that geography and institutions are not mutually exclusive and yet complementary. In particular, the literature has in general not addressed the ways in which geography and institutions are linked through population structure to account for American development history (section 2). We propose the *GeoPopulation-Institution hypothesis* (Figure 1) to establish the linkage. Our hypothesis embodies three claims:

1. Geographic factors, such as disease environment, soil and climate, and land abundance, would affect the willingness of Whites to migrate and the use of Black slaves in American regions/countries.[2]
2. Corresponding to the above willingness, domestic labor scarcity and political environment, transatlantic migration and slavery trade took place. The White-Black population structures in those regions/countries would be determined.
3. The slavery institution in America removed the incentive for Black slaves to improve their work. Hence a greater proportion of Black slaves in the population would have an adverse impact on technological progress and economic growth.

Our ultimate aim is to show this hypothesis explains development and divergence in American landscapes during the colonization era.

INSERT FIGURE 1 HERE

This paper is mainly divided into two parts. In the first part (sections 4-5), we develop a unified growth model which can replicate demographic-economic development in the Thirteen Colonies/United States during the colonization era. We construct a unified growth model with transatlantic migration and slavery trade (section 4). The model is distinct from traditional unified growth models (Galor and Weil 2000; Galor and Moav 2002) in two aspects, which are highly relevant to American development history (section 2.3). On the demography side, ours incorporates migration and slavery trade which can raise population stock within a region/country in ways other than natural increase. On the production side, technological progress depends on population composition compartmentalized by institution: slavery institution destines the Black slaves to not own property rights over their labor and wealth, therefore removing the Blacks' incentive to learn and improve their work; ceteris paribus, a greater Black population share implies slower technological progress (*population composition effect on technological progress*). We will also study the model's implications for territorial expansion and transatlantic slavery trade abolition in regard to the United States' development process (section 5).

In the second part (sections 6-7), we apply the model to explain the reversal of fortune across American regions/countries during the colonization era (Lindert and Williamson 2016; Engerman and Sokoloff 1997). By calibrating the unified growth model to the historical

[2] In this paper, the term "migration" or "migrants" refers to the voluntary White (European) labor flows from Europe to America, but not to the involuntary Black (African) labor flows from Africa to America.

experience of the United States and West Indies, we replicate the reversal of fortune within the United States (section 6) and among the two regions/countries (section 7.1). The region/country cursed by the reversal of fortune was characterized by slow natural population growth, low willingness of White migration, and small slavery trade cost. Then we put forward the GeoPopulation-Institution hypothesis to account for these parameter differences – albeit its higher initial productivity, the cursed region/country possessed unfavorable geographic factors that discouraged White migration (or encouraged the use of Black slaves). The colonial producers resorted to importing Black slaves if there was small political pressure against this. Through the population composition effect on technological progress, this hampered the region/country's economic progress in the long run. We will also apply the model and hypothesis to explain the relative economic decline of former Spanish colonies (section 7.2).

Our theory also implies that, after the abolishment of slavery institution in America by the late-nineteenth century, the population composition effect on technological progress would vanish. [3] Thereafter, regions/countries with larger production scale would enjoy faster technological progress, making a reversal of fortune less likely to occur. Hence the early Great Divergence pattern among American regions/countries emerged by the late-nineteenth century persists till today (section 8.2).

The paper proceeds as follows. The next section reviews the relevant literature. Section 3 discusses the historical backgrounds. Section 4 develops the benchmark model to study the development process in the Thirteen Colonies. Section 5 expands it to the Extended Model and studies the effects of territorial expansion and transatlantic slavery trade abolition on the United States' development. Section 6 applies the Extended Model to US-North and US-South, and we put forward the GeoPopulation-Institution hypothesis to account for the reversal of fortune between the two regions. Section 7 applies the model and hypothesis to explain the reversal of fortune across American countries. Section 8 highlights some discussion. Section 9 concludes.

2 RELATED LITERATURE

2.1 Geography hypothesis versus Institutions hypothesis

The geography hypothesis and the institutions hypothesis aim to explain the divergent growth experience across countries. There are at least three versions of the geography hypothesis. The first focuses on climate. Climate can affect individual work effort and productivity. For example, Montesquieu (1899[1748], 221-224) and Marshall (1895, 276) stated that people are more vigorous under cold climates. A related aspect is the disease environment. Sachs and Malaney (2002) posed that, malaria-endemic countries suffer from slower economic growth,

[3] Note the distinction between transatlantic slavery trade abolition and slavery institution abolishment. The former refers to the prohibition of slavery imports from other countries, while the latter refers to freeing of slaves within a country. For example, in the United States, transatlantic slavery trade was abolished in AD1807, while slavery institution was repealed only in AD1865. In this paper, the term "slavery trade" refers to transatlantic slavery trade but not to the internal slavery trade within a country.

because malaria adversely affects saving and investment, health and worker productivity, and so forth. Weil (2013, 467) mentioned that, because protohumans evolved in tropical areas in Africa, there was ample time for local parasites to develop and attack humans there, making Africa a less healthy and unproductive region.

The second focuses on natural topography. Adam Smith (1994[1776], 20-21) mentioned the importance of access to sea-coast and navigable rivers to a nation's market widening and development. Bloom et al. (2003) found that countries with favorable geography (cool, coastal countries with high, year-round rainfall) are more likely to escape from a poverty trap. Diamond (1997, 366, 407) advanced that, in addition to Eurasia's head start and wild animal and plant species, the east-west orientation of Eurasia has facilitated the diffusion of animals, plants, people, ideas and technology across the continent, because of the similar latitude and climate. On the contrary, the north-south orientation of America and Africa posed barriers to diffusion because of the changes in latitude and ecology. This gave the Eurasians developmental advantage by AD1492.

The third focuses on resource. This turns our attention to the resource blessing versus resource curse debate. For the blessing side, Levine (1987, 97) and Pomeranz (2000, 267) argued that the Industrial Revolution started in Britain because "England is built upon an underground mountain of coal", and its access to continental North American food supply brought on the rise of English manufactures. Habakkuk (1962, 12-13, 104-106) stated that land abundance and the resulting labor scarcity in the United States encouraged entrepreneurs to search for labor-saving innovations; this led to the rise of the American System of Manufacturers and rapid industrial progress in the United States during the nineteenth century. For the curse side, empirical evidence indicated that resource-abundant countries tended to grow slower in the recent decades (Sachs and Warne 1997; van der Ploeg 2011, 380). One explanation for this is the Dutch disease, where the blooming resource sector would lead to deindustrialization through real exchange rate appreciation (Corden and Neary 1982); via learning-by-doing this could contribute to long-term welfare loss (Krugman 1987).

The institutions hypothesis takes a rival view against "geography is destiny". North (1990, 3) defines institutions as "rules of the game in a society" that shape human interaction.[4] North and Thomas (1973, 1-2) stated that efficient economic organization, which entails the establishment of institutional arrangements and property rights that provide economic initiatives, is the key to economic growth. Acemoglu and Robinson (2012) argued that nations fail because of the existence of extractive political institutions, which incur extractive economic institutions that create entry barriers and unfair regulations, impeding economic progress for the masses. In contrast, societies that feature inclusive political institutions give rise to inclusive economic institutions, which secure property rights and promote entrepreneurship, and hence economic

[4] Adam Smith (1994[1776], 484-485) stated that, the wealth of society equals the exchangeable value of the whole produce of its industry. Free market system, led by the "invisible hand", would align the interests of individuals with the society. It is the individual's endeavors to purse activities that are most highly valued by the others, that create the greatest wealth of the society. Hayek (1963[1960], 231) mentioned that freedom of economic activity under the rule of law ("free system") would make continuous growth of wealth and technological knowledge possible.

growth. Hall and Jones (1999) found evidence that institutions and government policies drive cross-country differences in capital accumulation, productivity and per worker output.

The institutions hypothesis has been applied to account for the reversal of fortune across American countries. For example, North et al. (2000) stated that, in post-Revolutionary United States, the credible system of limited government based on the full separation of powers had laid the cornerstone of political order and market-preserving federalism, providing the basis for long-run growth. In contrast, in colonial Spanish America, the Crown focused on short-term resource exploitation, leaving its colonies with little experience in autonomous governance, leading to political disorder and poor economic performance after their independence. Engerman and Sokoloff (1997) proposed that it was the interplay between resource thrust or inequalities and the governmental policies toward maintaining them that shaped economic divergence among American countries. For the within-United States divergence, they proposed that US-South lagged behind US-North in evolution of political and economic institutions that promoted widespread commercialization and market development, causing the region's relative decline in the nineteenth century.

In the recent years, the institutions hypothesis has confronted the geography hypothesis in econometrics fronts. Acemoglu et al. (2001) raised that Europeans were more likely to establish extractive institutions in colonies where they faced higher settler mortalities. Such institutions were persistent and adversely affected long-run economic performance. They used European settler mortality rates as an instrument for current institutions in their per capita GDP regressions, and found that geography variables, such as latitude, lose significance once institutions are controlled for. They viewed this as evidence in favor of the institutions hypothesis over the geography hypothesis. Employing similar procedures, Easterly and Levine (2003), Rodrik et al. (2004) arrived at the same conclusion.

Sachs (2003) criticized the operationalization of geography variables in the above works; in particular there are too few geography variables to capture overall geographic characteristics, subjecting the regressions to the risk of omitted-variable errors. Also, the dependent variable of the regressions in the above works was contemporaneous income level instead of growth rate of the economy across time. Once growth rate of per capita GDP is used as the dependent variable, institutions variable loses significance (Glaeser et al. 2004, 283).[5] On the other hand, Albouy (2012) doubted Acemoglu et al. (2001)'s results because of data reliability and methodological issues (See Acemoglu et al. (2012) for the defense).

In this paper, we argue that geography and institutions, rather than being crashing views, take inseparable roles in understanding American development and divergence from the long-run perspective. Population provides the key linkage between the two (section 6.2).

2.2 Population: Transatlantic migration and slavery trade

In the recent years, the literature has studied the channels through which population fosters long-term development. For example, Kremer (1993) stated that, since the melting of the polar

[5] Additionally, Glaeser et al. (2004, 295) showed that, even using per capita GDP as the dependent variable, institutions variable loses explaining power once human capital is included as another explanatory variable in income regressions.

ice caps in around 10,000BC, continents with greater land area, and hence larger initial population experienced faster technological progress before AD1500. Spolaore and Wacziarg (2009, 2014) proposed that the greater the population genetic distance relative to the world technological frontier is, the slower technological diffusion from the frontier and the lower current per capita income in a country would be. Ashraf and Galor (2013) posited that the low genetic diversity of native American populations and the high genetic diversity of African populations relative to the European and Asian populations, have detrimental effects on development. Putterman and Weil (2010) posed that, history of a population's ancestors matters more than the history of the place they live today in determining their current per capita income. While reversal of fortune for colonized countries as territories is evidential, there is persistence of fortune for people and their descendants (Chanda et al. 2014).

Compared to the above literature, we stress the roles of transatlantic European migration and African slavery trade in fostering American development during the colonization era. Engerman and Sokoloff (2013, 101) stated that, "one of the most fundamental consequences of European colonization may have been in altering the composition of the populations in the societies colonized". Easterly and Levine (2015) found a strong positive relationship between European share of population during colonization ("Euro share") and the level of per capita income today in non-European countries. Landes (1998, 311) argued that Spanish America fell in terms of wealth relative to British America because the Spanish Crown kept European outsiders away from entering its colonies, depriving skill and knowledge progress in Spanish America. On the other hand, American regions/countries where African descendants made up significant population shares by the nineteenth century had been cursed by the reversal of fortune.[6] How was population structure in an American region/country determined, and how did it affect the region/country's economic fortune? We will develop a unified growth model with transatlantic migration and slavery trade to answer these questions (sections 4.1-4.2).[7]

2.3 Unified growth theories

Since the turn of the new millennium, growth economists have shifted their attention to explaining long-term development patterns through the unified growth theories. Galor and Weil (2000) and Galor and Moav (2002) suggested that the inherent Malthusian interaction between population size/composition and technology level speeds up the pace of technological progress, and eventually will lead to industrialization and demographic transition. The literature has evolved to incorporate more structural changes that went along with demographic-economic development. Unified growth models with physical and human capital accumulation (Galor and Weil 1996; Galor and Moav 2006), inequality (Galor and Moav 2004; Galor et al. 2009), trade

[6] For example, from Table 1, at the turn of the nineteenth century, African descendants occupied more than half of the populations in Barbados (80.7%), Venezuela (62%), Cuba (51%) and Brazil (61.2%). In AD1860, African descendants contributed to about one-third of population in US-South (37.7%).

[7] In Africa, there is evidence that historical slavery trade adversely affected economic performance today (Nunn 2008). One channel would be that African Blacks whose ancestors were heavily raided during the 400 years of slavery trade are less trusting today (Nunn and Wantchekon 2011).

(Galor and Mountford 2006, 2008), child labor laws (Hazan and Berdugo 2002; Doepke 2004), mortality (Lagerlöf 2003; Voigtländer and Voth 2013), structural transformation (Strulik and Weisdorf 2008; Vollrath 2009) and female empowerment (Diebolt and Perrin 2013a, 2013b) have been proposed.

However, in the above works, the role of international labor movement was ignored, and this is especially important in early American development history. In the demography side, the native Indians did not contribute to the buildup of population stock in most American countries during the colonization era.[8] Instead, the population increase came mainly from transatlantic migration and slavery trade, as well as the natural increase of the migrated Europeans (Whites) and imported Africans (Blacks). Table 1 reproduces Engerman and Sokoloff (1997)'s population composition estimates in selected American regions/countries at different time points during the colonization era. By the turn of the nineteenth century, most of the New World economies were populated with Whites and Blacks rather than with Indians. In the production side, we saw from the past subsection that Euro share had a strong positive correlation with economic development (Easterly and Levine 2015). Therefore any unified growth theory aiming to explain long-run American development and divergence should take transatlantic movement of European and African labor into account (sections 4 and 8.5).

INSERT TABLE 1 HERE

In another dimension, relative to the Eastern Hemisphere, there was less work done on simulating long-run economic development in the Western Hemisphere using unified growth models. See exceptions from Hansen and Prescott (2002), Doepke (2004), Lord and Rangazas (2006) and Mourmouras and Rangazas (2009). But they either did not specify simulation time frames or placed the starting point after AD1800. This paper focuses on the New World economies during the colonization era, in particular AD1700-AD1860 (sections 4.3, 5, 6.1 and 7).

3 HISTORICAL CONTENT AND BACKGROUND

Section 3.1 reviews per capita income and demographic development in British America, including the reversal of fortune between US-North and US-South, during the eighteenth and early-nineteenth centuries. Section 3.2 documents the reversal of fortune among American countries, and overviews the political environments in these countries during the early Modern Period. The historical data will be used to calibrate our models in later sections of this paper.

3.1 Economic development and Population evolution in British America

3.1.1 The Thirteen Colonies / United States

Table 2 shows Lindert and Williamson (2016)'s estimates of real per capita income in the Thirteen Colonies during AD1650-AD1774. In this paper, US-North refers to colonies/states north of the Mason-Dixon line (New England and Middle Colonies), while US-South to those

[8] Denevan (1992, xxix) postulated that the native Indian population "dropped from about 53.9 million in 1492 to only about 5.6 million by 1650", that is, about 90% depopulation rate within around 150 years.

south of the Mason-Dixon line (Upper South and Lower South).[9] New England, which mainly traded its fishery and timber products, possessed per capita income levels similar to that of Britain and grew slowly throughout AD1650-AD1774. Middle Colonies, which focused on exporting its mixed farming products, was stagnating but possessed higher income levels than New England during the eighteenth century. The Upper South and Lower South, which specialized in tobacco and rice production respectively, were much wealthier than the northern colonies throughout the colonial period, but were suffering from per capita income declines at the same time.

INSERT TABLE 2 HERE

During the American Revolution (AD1775-AD1783), the Thirteen Colonies declared independence in AD1776 and turned into the United States of America. Table 3 shows Lindert and Williamson (2013)'s estimates of real per capita income growth rate in the Thirteen States during the early Republic period (AD1774-AD1840).

INSERT TABLE 3 HERE

The Thirteen States suffered from per capita income downswing in the two decades following the Revolutionary Wars, with US-South witnessing the sharpest decline. In the first four decades of the nineteenth century, the Thirteen States grew at an impressive average rate of 1.56% per annum. US-North, in particular New England, grew much faster than US-South did. Combining the estimates from Tables 2-3, Figure 2A depicts real per capita income evolution in the Thirteen Colonies/States during AD1650-AD1840. It reveals the reversal of fortune between US-North (solid lines) and US-South (dashed lines): US-North, which was initially poorer during the seventeenth and eighteenth centuries, surpassed US-South by AD1840. Figure 2B shows a comparison of income evolution between the Thirteen Colonies/States and Britain during AD1650-AD1840. In general the Thirteen Colonies was wealthier than Britain during the colonial period. The British Industrial Revolution during the late-eighteenth century allowed the motherland to outperform the newly established Republic.

INSERT FIGURE 2 HERE

Next we come to Galenson (1996)'s estimates of White-Black population evolution in the Thirteen Colonies. Table 4 shows the White populations in US-North, US-South (and West Indies), with the numbers in parentheses denoting the White population share, in each decade during AD1620-AD1770. From the settlement in Jamestown till the eve of the American Revolution, the White populations were increasing in both US-North and US-South, with the former rising about twice faster than the latter.

INSERT TABLE 4 HERE

The White population growth was mainly fueled by natural increase and transatlantic migration. Table 5 shows the White migration from British Isles to British America in each decade from AD1630 to AD1770. During this time frame, the total number of White migrants to US-North was about half that to US-South. This implies that US-North had a higher natural population growth rate.[10]

[9] Note that the definitions of New England, Middle Colonies, Upper South and Lower South vary in our sources (see Tables 2-4). Unless specified, we will stick to definitions stated in Table 4.

[10] One factor that contributed to the higher natural population growth rate in US-North was the lower mortality rate there. See Table A.1 for Wells (1992)'s estimates of life expectancy among

INSERT TABLE 5 HERE

Table 6 shows the Black populations in US-North, US-South (and West Indies), with the numbers in parentheses representing the Black population share, in each decade during AD1650-AD1770. Before the AD1680s, the Black populations grew slowly in US-North and US-South. After that, this trend continued in US-North, and the Blacks constituted less than 5% of the population in US-North in most of the time. In contrast, the Black population grew fast in US-South. By the eve of the American Revolution, US-South possessed a Black population which was eight times larger than that in US-North, and the Blacks dominated 41% of the US-South population.

INSERT TABLE 6 HERE

The Black population growth was mainly fueled by natural increase and transatlantic slavery trade. Table 7 shows the number of Blacks flowing to British America in each decade from AD1650 to AD1770. We interpret the data reflecting the number of African slaves imported to British America.[11] Throughout the seventeenth and eighteenth centuries, US-North almost did not import slaves. On the other hand, US-South was importing slaves in every decade except the decade of American Revolution. Throughout these two centuries, the total number of Blacks imported to US-South (219,000) was about two-thirds the number of Whites migrating to US-South (328,000).

INSERT TABLE 7 HERE

3.1.2 Labor market Institutions

We briefly review the labor market institutions in British America. The first was indentured servitude. More than half of British migrants relied on indentured servitude contracts to cover the migration expenditure (Allen et al. 2012). Indentured servitude was a credit system where prospective servants paid for their passages to America by signing contracts with recruiting agents, promising to work in a particular colony under stated conditions for a specified number of years. The servants would then be shipped to the designated colony. The recruiting agents would sell, in a second market, the contracts to American planters or farmers, who would provide maintenance to the servants during the contract terms. The conditions of the servitude were regulated by local American courts. The servants would be freed after the contracts expired (Galenson 1981a).

Another labor market institution was slavery. British America obtained overseas slaves through transatlantic slavery trade before the abolitions in the United States and in the British

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selected regions in the Thirteen Colonies/United States during the eighteenth century. In general US-North was a healthier place than US-South and the people there enjoyed longer life expectancies.

[11] We interpret all Blacks as slaves in British America during the eighteenth and early-nineteenth centuries. The two are conceptually different, but statistics indicates that they were similar. For example, U.S. Bureau of the Census (1909, Table 60; 1975, series A 6-8)'s data indicated that 18% of United States population were slaves in AD1790, which closely matches the 21% nationwide Black population share implied by our AD1770 data from Tables 4 and 6. Similarly, 13% of United States population were slaves in AD1860, which closely matches the 14% nationwide Black population share in the United States in AD1860 (from our Table 1).

Empire in AD1807. The transported people were usually enslaved, kidnapped and raided Africans (Thornton 1996). Slaves were treated as properties of their owners; their legal status involved serving for life as would their progeny (Galenson 1981a). The British common law did not protect slaves from mistreatment by their masters. In contrast, the slave owners had absolute power and authority to force the slaves to work, buy and sell them, use them as collaterals or gifts as they wished (Finkelman 2012).

3.1.3 The West Indies

The West Indies was another region that was characterized by the reversal of fortune, when compared to the United States. Due to data availability, we take Coatsworth (2005)'s per capita income estimates for the Caribbean countries to proxy their British West Indies counterparts (Table 8 in section 3.2.2). In AD1700, West Indies ($650 in AD1990 dollars) was wealthier than the future United States ($527 in AD1990 dollars). However, the United States ($1,231 in AD1990 dollars) overtook the West Indies ($636 in AD1990 dollars) by AD1820.

From the British West Indies panels in Tables 4-7, since the AD1660s up till the eve of the American Revolution, the White population in West Indies remained roughly constant (Table 4). The same applied to the number of White migrants from British Isles to West Indies (Table 5). On the other hand, the Black population in West Indies was increasing over the same time frame, and it made up more than 90% of the total population by AD1770 (Table 6). The Black population increase in West Indies was mainly fueled by slavery import (Table 7).[12]

3.2 Economic growth and Political situation in American countries

3.2.1 Reversal of fortune among American countries

There is a negative correlation between economic prosperity in AD1500 and today among American countries. Figure 3 depicts the plot of log per capita income in AD2008 against urbanization rate in AD1500, which is our proxy for economic prosperity in AD1500, for 22 American countries. In general a more prosperous American country in AD1500 would become a relatively poor country today.[13]

INSERT FIGURE 3 HERE

3.2.2 Economic and political environments in American countries

We categorize the American countries into three groups: Spanish-type resource-exploitation countries, Portuguese-type sugar-exporting countries and United-States-type White-populated

[12] In section 7.1, we will calibrate the White and Black natural population growth rates in British West Indies, which are found to be negative during AD1700-AD1780. Hence, the roughly constant White population and increasing Black population must have been supplied by transatlantic migration and slavery trade.

[13] Our sample includes 22 countries, namely Argentina (AR), Bolivia (BO), Brazil (BR), Canada (CA), Chile (CL), Colombia (CO), Costa Rica (CR), Dominican Republic (DO), Ecuador (EC), El Salvador (SV), Guatemala (GT), Haiti (HT), Honduras (HN), Jamaica (JM), Mexico (MX), Nicaragua (NI), Panama (PA), Paraguay (PY), Peru (PE), Uruguay (UY), the United States (US) and Venezuela (VE).

countries. Table 8 shows Coatsworth (2005)'s per capita income evolution among these three groups of countries from AD1500 to AD2000.

INSERT TABLE 8 HERE

Spanish-type resource-exploitation countries refer to the former Spain-ruled American colonies. They made up most of Central America and South America (except Brazil). In the early-sixteenth century, Aztec and Inca, the most advanced civilizations in America at that time, were conquered by Spain. Since then Spain adopted a policy of conquest imperialism. The Aztec and Inca elites and their priesthood were wiped out. Churches and convents were built to replace the old religious regimes. There was a stringent social distinction between the ruling elites and the native Indians. The former were granted land and indigenous population. The latter had no legal rights, access to land and education, but were to supply forced labor (Maddison 2003, ch.HS-4; Maddison 2007, ch.2). To protect the persistence and stability of the elites, Spain adopted restrictive migration policies, requiring citizens to meet formidable requirements for acquiring permission to move to the New World (Engerman and Sokoloff 1997, 2000). From Table 8, these countries were more prosperous than the future United States in AD1500, but were surpassed by the United States by AD1820.

Portuguese-type sugar-exporting countries refer to Brazil and the former Caribbean colonies. Brazil's coastline, from Natal to Florianopolis, was suitable for sugarcane cultivation. During the sixteenth century, Portugal developed Brazil into an export economy based on sugar plantation. The growing labor scarcity problem increased Portugal's dependence on African slavery for Brazil's labor supply (Galloway 1989, 71-72). In the seventeenth century, England, France and the Netherlands seized Caribbean islands from the Spanish Empire. Similar to Portuguese-Brazil, Caribbean islands also possessed favorable soils and climates for growing sugar, but thin domestic population. The three European powers copied Portuguese-Brazil's model of slave-based sugar-plantation export-economy to the Caribbean islands (Maddison 2003, ch.HS-4). Sugar brought the Caribbean islands prosperity in the seventeenth and eighteenth centuries. From Table 8, the Portuguese-type countries were wealthier than the future United States in AD1600, but were surpassed by AD1820.

United-States-type White-populated countries refer to the future United States and Canada. These places were the most thinly populated areas in America at the outset of the colonization era (Acemoglu et al. 2002, Appendix 3). They were not endowed with rich resources or soils and climates that favored the production of staple crops (except tobacco and rice production in US-South). There was hence less demand for importing slavery labor to work in these countries. As a result, these countries relied mainly on European migrants and their descendants to supply work force (Engerman and Sokoloff 1997, 2000). From Table 8, although these countries started off as the poorest regions in AD1500-AD1600, they became the richest places in America by AD1820.

4 THE BENCHMARK MODEL (AD1700-AD1780)

In this section, we develop the benchmark *unified growth model with transatlantic migration*

and slavery trade, and simulate the development process of the Thirteen Colonies during the eighteenth century. The model will be extended in different time- and spatial-settings in the next three sections.

4.1 Model Setting

Suppose that the world economy consists of two countries, country A ("colony") and country B ("home"). Country A is an American colony of an European country B; they are geographically separated by the Atlantic Ocean. Africa is a region where Black slavery labor can be obtained. The "colonial producer" owns the land in country A, while the "home landlord" owns the land in country B. They hire labor to produce, and earn land rents in return. There are two types of individuals: "Whites" (European descendants) and "Blacks" (African descendants). Each individual is endowed with one unit of labor which is supplied inelastically. Time is discrete and indexed by t. Each time period spreads for 10 years.

4.1.1 Demography side

Europeans in country B enjoy the freedom to migrate to country A. Following Harris and Todaro (1970), we hypothesize that the number of migrants moving from country B to country A at time t, M_t, is a positive function of the country A-country B expected wage differential at time t:

(1) $$M_t = m([w_t^A]^e - [w_t^B]^e) \ , \ m > 0 \ ,$$

where $[w_t^A]^e$ and $[w_t^B]^e$ are the expected wages in country A and in country B at time t respectively.[14] We interpret m as a measure of willingness to migrate from country B to country A; it contains all factors other than wage that affect the number of migrants, for example, mortality rate, forms of work organization, racial composition of labor force in American destination (Galenson 1981b, 144-145). We make the rational expectation assumption: the expected wage differential at time t $([w_t^A]^e - [w_t^B]^e)$ equals the actual wage differential at time t, $(w_t^A - w_t^B)$, where w_t^A and w_t^B are the wages in the two countries at time t. Hence (1) becomes:

(2) $$M_t = m(w_t^A - w_t^B) \ .$$

Next we come to demographic process in the two countries. There are two types of individuals in country A (colony): the Whites and the Blacks. The total population size in country A at time t, L_t^A, is:

(3) $$L_t^A = L_t^H + L_t^F \ ,$$

where L_t^H is the White population size in country A at time t, L_t^F is the Black population size in country A at time t.

The White population size in country A at time t, L_t^H, evolves from two sources: natural increase and current transatlantic migration:

(4) $$L_t^H = \left(1 + g^{L^H}\right)L_{t-1}^H + M_t \ ,$$

where g^{L^H} is the exogenous White natural population growth rate in country A, $\left(1 + g^{L^H}\right)L_{t-1}^H$

[14] Harris and Todaro (1970, 129) studied rural-to-urban migration. They hypothesized that the number of migrants moving from rural area to urban area is a positive function of urban-rural expected wage differential. Using their notations:

$\dot{N}_u = \psi(w_u^e - w_A)$, where $\psi' > 0, \ \psi(0) = 0,$

where $\dot{N}_u$ is the time derivative of urban population (migration), w_u^e is the expected urban wage, w_A is the rural wage, $\psi(.)$ is a positive increasing function. In our equation (1), we assume $\psi(.)$ to take a linear form for simplicity.

is the natural increase in White population at time t, M_t is the endogenously determined number of transatlantic migrants at time t. The White population size in country A at $t = 1$, L_1^H, is historically given.

Similarly, the Black population size in country A at time t, L_t^F, evolves from two sources: natural increase and current transatlantic slavery trade:

(5) $$L_t^F = \left(1 + g^{L^F}\right)L_{t-1}^F + Q_t \ ,$$

where g^{L^F} is the exogenous Black natural population growth rate in country A, $\left(1 + g^{L^F}\right)L_{t-1}^F$ is the natural increase in Black population at time t, Q_t is the endogenously determined number of Black slaves imported at time t. The Black population size in country A at $t = 1$, L_1^F, is historically given.

There is only one type of individuals in country B (home): the Whites. We assume that the home country would never import African slaves. The population size in country B at time t, L_t^B, equals the natural increased amount minus the number of transatlantic migrants:

(6) $$L_t^B = \left(1 + g^{L^B}\right)L_{t-1}^B - M_t \ ,$$

where g^{L^B} is the exogenous natural population growth rate in country B. The population size in country B at $t = 1$, L_1^B, is again historically given.

To simplify our analysis, we make the small colony assumption. When the number of migrants is much smaller than the population size in country B (home), transatlantic migration would hardly affect the population size at home.[15] Hence (6) can be approximated by:

(7) $$L_t^B = \left(1 + g^{L^B}\right)L_{t-1}^B \ .$$

4.1.2 Production side

The home landlord and colonial producer make production decisions subject to technological and institutional constraints. For production technologies, in country B (home), output at time t is produced with Cobb-Douglas technology, using labor and home land as inputs:

(8) $$Y_t^B = z_t^B (L_t^B)^{\alpha} (T^B)^{1-\alpha} \ , \ \alpha \in (0,1) \ ,$$

where z_t^B is technology level in country B at time t, T^B is the amount of land in country B.

Similarly, in country A (colony), output at time t is produced according to Cobb-Douglas technology, using labor and colonial land as inputs:

(9) $$Y_t^A = z_t^A (L_t^A)^{\alpha} (T^A)^{1-\alpha} \ , \ \alpha \in (0,1) \ ,$$

where z_t^A is technology level in country A at time t, T^A is the amount of land in country A.

For institution, country B possesses free labor market: at each time t, by inelastically supplying one unit of labor, each White worker earns a wage income of w_t^B. The home landlord owns land and production technology in country B. He or she decides how many domestic labor to hire to maximize land rent at home, taking home wage as given:

(10) $\max_{L_t^B} Y_t^B - w_t^B L_t^B$ subject to (8).

First order condition of (10), together with home labor market clearing implies:

(11) $$w_t^B = z_t^B \cdot \alpha (L_t^B)^{\alpha-1} (T^B)^{1-\alpha} \ ,$$

[15] For example, from Maddison (2008)'s estimates, in AD1700, British Isles (United Kingdom and Ireland) had a population of about 10 million. From our Table 5, the average decennial migration from British Isles to British America during AD1700-AD1770 was only about 18 thousand, which was less than 0.2% of British Isles' population in AD1700.

That is, home wage equals marginal product of home labor at each time t.

Colonial labor market features free White labor and Black slavery: at each time t, every individual inelastically supplies one unit of labor; in return, each White worker earns a wage income of w_t^A, while each Black worker gets nothing (slavery institution). The colonial producer owns land and production technology in country A, and maximizes the land rent there. Besides hiring domestic and migrant workers, he or she possesses one more choice variable: to engage in transatlantic slavery trade and import African slaves. We assume the cost of engaging in transatlantic slavery trade is increasing in the number of slaves imported and takes the form of $f \cdot (Q_t)^2$, where f is a positive constant.[16] The slavery trade cost parameter f reflects the direct cost of engaging in trading activity, as well as political pressure against slavery imports. The colonial producer decides the numbers of White labor to hire, and Black slaves to import, taking colony wage as given:

(12) $\max_{L_t^H, Q_t} Y_t^A - w_t^A L_t^H - f(Q_t)^2$ subject to (9), (5) ,

where $w_t^A L_t^H$ is the total wage payment to the Whites at time t, $f(Q_t)^2$ is the slavery trade cost at time t. No wage payment is made to the Blacks for all time t. First order condition of (12), together with White and Black labor market clearings in the colony, implies:

(13) $w_t^A = z_t^A \cdot \alpha (L_t^A)^{\alpha-1} (T^A)^{1-\alpha}$,

(14) $z_t^A \cdot \alpha (L_t^A)^{\alpha-1} (T^A)^{1-\alpha} = 2 f Q_t$.

Equation (13) means colony wage equals marginal product of Whites in colony, while (14) states marginal product of Blacks in colony equals marginal slavery trade cost at each time t.

4.1.3 Technological progress

Technological progress occurs at home and in the colony in every period. We assume the technology in country B (home) is more advanced than that in country A (colony). Home technological progress comes from learning-by-doing externality during production process (Arrow 1962; Matsuyama 1992; Strulik and Weisdorf 2008).[17] Technology level in country B at time $t+1$, z_{t+1}^B, is:

(15) $z_{t+1}^B = z_t^B + \mu Y_t^B$, $\mu > 0$.

The μY_t^B term represents learning-by-doing. The formulation has the implication that an increase in factor input would accelerate technology growth. Technology level in country B at $t = 1$, z_1^B, is historically given.

For country A (colony), technological progress comes from two sources: learning-by-doing externality during production process and technology diffusion from country B (home). Population composition compartmentalized by the slavery institution affects the pace of technological progress. Technology level in country A at time $t+1$, z_{t+1}^A, is:

(16) $z_{t+1}^A = z_t^A + \frac{L_t^H}{L_t^A} \cdot [\mu Y_t^A + d(z_t^B - z_t^A)]$, $\mu, d > 0$,

[16] We assume slavery trade cost takes a quadratic rather than a linear form, otherwise the equilibrium system will have an indeterminate solution.

[17] We model technological progress as a result of learning-by-doing rather than R&D. Crafts (1995, 761) stated that during the era of British Industrial Revolution, "Arrow-like learning by doing was much more important relative to intentional, profit-seeking R&D than in today's world".

The μY_t^A term is again the learning-by-doing component. The $d(z_t^B - z_t^A)$ term is the technology diffusion component, which reflects the advantage of being a relatively backward country (Gerschenkron 1962; Nelson and Phelps 1966). The White population share (or "Euro share") term $\frac{L_t^H}{L_t^A}$ captures the "social capability" of country A to engage in technological progress (Ohkawa and Rosovsky 1973, 212; Abramovitz 1986); that is, how conducive the population in country A is to improving technological practice through learning-by-doing and technology diffusion.[18] We argue that, since the Blacks and their descendants had been deprived of the title to their human capital and wealth, they have no incentive to learn and improve their work.[19] Hence, the greater the Black population share, the slower learning-by-doing and technology diffusion would be, relative to the full potential rate $\frac{[\mu Y_t^A + d(z_t^B - z_t^A)]}{z_t^A}$.[20] Technology level in country A at $t = 1$, z_1^A, is historically given.

To recap: from (16), ceteris paribus, an increase in the number of European migrants M_t speeds up colonial technological progress through a production scale effect (via the increase in μY_t^A term) and a population composition effect (via the increase in $\frac{L_t^H}{L_t^A}$ term). On the other hand, ceteris paribus, an increase in imported African slaves Q_t accelerates colonial technological progress through the production scale effect, but decelerates it through the population composition effect. The *population composition effect on technological progress* will be crucial in explaining reversal of fortune in American landscapes during the colonization era (sections 6-7).

4.1.4 Per capita income

Lastly, denote per capita incomes in country A and in country B at time t as y_t^A and y_t^B respectively:

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[18] Easterly and Levine (2015) posited that a higher Euro share had lasting positive impacts on economic development in colonized countries, because the Europeans brought along with them human capital, technology, familiarity with global markets, and political institutions during colonization.

[19] Adam Smith (1994[1776], 742) stated that, "[s]laves, however, are very seldom inventive; and all the most important improvements … have been the discoveries of freemen."

Emerson (1844) declared that "[s]lavery is no scholar, no improver".

Fogel and Engerman (1989, 108) posed that, "under the unbridled exploitation of slavery … the blacks had little incentive to improve themselves".

Acemoglu and Robinson (2012, 75) stated that, "Barbados did not have inclusive economic institutions, since two-thirds of the population were slaves with no access to education or economic opportunities, and no ability or incentive to use their talents or skills".

[20] Nelson and Phelps (1966, 73) hypothesized that technology growth of a country takes the form of $\dot{A}_t = \Phi(h) \cdot [\bar{A}_t - A_t]$, where A_t is the country's technology level at time t, $\bar{A}_t$ is the frontier technology level at time t, h is the current level of human capital, $\Phi(.)$ is a positive increasing function of h. Benhabib and Spiegel (1994, 155), Aghion and Howitt (2009, 298) stated the technology growth equation in a more general form of $\dot{A}_t = \phi(h) \cdot g_t + \Phi(h) \cdot [\bar{A}_t - A_t]$, where $\phi(.)$ is another positive increasing function of h, g_t is the growth rate originating from domestic innovation in the country. Our equation (16) takes a similar form by replacing h by White population share (Euro share) in the economy, replacing g_t by a learning-by-doing term, and assuming $\Phi(.)$ and $\phi(.)$ to take linear forms.
Note that the White and Black population shares always sum up to one.

(17) $y_t^A \equiv \frac{Y_t^A}{L_t^A}$, and

(18) $y_t^B \equiv \frac{Y_t^B}{L_t^B}$.

From (17) and (18), we have the standard population dilution effect on per capita income: given total output in the economy, a larger population size implies a smaller per capita income for each individual.

To summarize, the distinctive features of our unified growth model comprise transatlantic labor movement, which raises population stock in a country through channels other than natural increase (section 4.1.1), and slavery institution, which compartmentalizes the population, depriving the Black labor at the cost of overall productivity advancement in the colony (sections 4.1.2-4.1.3).

4.2 Equilibrium Analysis

We define the equilibrium growth path of the economy. The first period of our model is indexed by $t = 1$, with initial conditions $\{L_1^H, L_1^F, L_1^B;\ z_1^A, z_1^B\}$. The equilibrium constitutes sequences of production variables $\{Y_t^A, Y_t^B;\ y_t^A, y_t^B\}_{t=1}^{\infty}$, technological variables $\{z_t^A, z_t^B\}_{t=1}^{\infty}$, population variables $\{L_t^A, L_t^H, L_t^F, L_t^B;\ M_t, Q_t\}_{t=1}^{\infty}$ and wages $\{w_t^A, w_t^B\}_{t=1}^{\infty}$ which satisfy:

A) Home landlord and colonial producer rent maximization and labor market clearing: $\{w_t^A, w_t^B, Q_t\}$ satisfy (11), (13) and (14) at time t.

B) Output production: Given current technology levels $\{z_t^A, z_t^B\}$, land and labor inputs $\{T^A, T^B, L_t^A, L_t^B\}$, output in the two countries $\{Y_t^A, Y_t^B\}$ are obtained from production functions (9) and (8) at time t.

C) Transatlantic migration: Given wages $\{w_t^A, w_t^B\}$, number of migrates M_t is determined by (2) at time t.

D) Population evolution: $\{L_t^A, L_t^H, L_t^F, L_t^B\}_{t=1}^{\infty}$ evolve according to (3), (4), (5) and (7).

E) Technology evolution: $\{z_t^A, z_t^B\}_{t=1}^{\infty}$ evolve according to (16) and (15).

F) Per capita income: $\{y_t^A, y_t^B\}_{t=1}^{\infty}$ are defined by (17) and (18).

Propositions 1 and 2 state two internal adjustment mechanisms in our model: they show how technological progress and natural population growth drive the evolution of numbers of migrants and imported slaves across time:[21]

Proposition 1 (Technology growth effect on migration and slavery trade): *(i)* Ceteris paribus, technological progress in country A raises the numbers of migrants and slaves imported to country A, that is, $\frac{\partial M_t}{\partial z_t^A} > 0$ and $\frac{\partial Q_t}{\partial z_t^A} > 0$. *(ii)* On the other hand, technological progress in country B reduces the number of migrants and raises the number of slaves imported to country A, that is, $\frac{\partial M_t}{\partial z_t^B} < 0$ and $\frac{\partial Q_t}{\partial z_t^B} > 0$.

Proof: See Appendix 1.

[21] See Appendix 2 for more details.

Explanation: *(i)* Technology growth in colony raises colony wage and marginal product of Black labor, thereby raising M_t and Q_t. *(ii)* Technology growth at home raises home wage and reduces migrants M_t. Marginal product of Black labor in colony increases and so Q_t rises.

Proposition 2 (Natural population growth effect on migration and slavery trade): *(i)* Ceteris paribus, White natural population growth in country A reduces the numbers of migrants and slaves imported to country A, that is, $\frac{\partial M_t}{\partial\left(1+g^{L^H}\right)L_{t-1}^H} < 0$ and $\frac{\partial Q_t}{\partial\left(1+g^{L^H}\right)L_{t-1}^H} < 0$. *(ii)* Similarly, Black natural population growth in country A reduces the numbers of migrants and slaves imported to country A, that is, $\frac{\partial M_t}{\partial\left(1+g^{L^F}\right)L_{t-1}^F} < 0$ and $\frac{\partial Q_t}{\partial\left(1+g^{L^F}\right)L_{t-1}^F} < 0$. *(iii)* On the other hand, natural population growth in country B raises the number of migrants and reduces the number of slaves imported to country A, that is, $\frac{\partial M_t}{\partial\left(1+g^{L^B}\right)L_{t-1}^B} > 0$ and $\frac{\partial Q_t}{\partial\left(1+g^{L^B}\right)L_{t-1}^B} < 0$.

Proof: See Appendix 1.

Explanation: *(i), (ii)* Rising natural population in colony reduces colony wage and marginal product of Black labor, thereby lowering M_t and Q_t. *(iii)* Natural population growth at home lowers home wage and increases migrants M_t. Marginal product of Black labor in colony decreases and so Q_t falls.

4.3 Calibration and Simulation: the Thirteen Colonies AD1700-AD1780

We calibrate the benchmark model and simulate demographic-economic development of the Thirteen Colonies during AD1700-AD1780 (section 3.1.1). We identify country A as the Thirteen Colonies and country B as Britain, which includes today's United Kingdom and Ireland.[22] Parameters and initial conditions are chosen to match historical land areas, population levels and growth, income levels and growth in the two countries, as well as migration and slavery import into the Thirteen Colonies. Each model period corresponds to 10 years.

Land area: For the Thirteen Colonies, we sum the land areas in today's Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, Georgia, North Carolina, and South Carolina provided by U.S. Bureau of the Census (2012, Table 18). For Britain's case, we sum the land areas of today's United Kingdom and Ireland provided by the Central Intelligence Agency, or CIA (2016). The land areas of the Thirteen Colonies and Britain are $904{,}554km^2$ and $310{,}813km^2$ respectively.

Initial population: For the Thirteen Colonies, using the AD1700 data from Tables 4 and 6, we take initial White population as $L_1^H = 240{,}000$, and initial Black population as $L_1^F = 22{,}000$. For Britain, we sum the AD1700 population estimates for the United Kingdom and Ireland provided by Maddison (2008) to obtain $L_1^B = 10{,}490{,}000$.

[22] Note that we treat United Kingdom and Ireland as one united country in the British Isles. This allows us to match the migration data from Table 5 (the White migration from British Isles to British America). Historically, United Kingdom and Ireland integrated into one country under the name of "United Kingdom of Great Britain and Ireland" during AD1801-AD1922.

Income level: From Table 2, we take initial per capita income of the Thirteen Colonies and Britain in AD1700 to be 3.45 and 2.06 respectively. Using (9) and (17), we calibrate z_1^A by $y_1^A L_1^A = z_1^A (L_1^A)^\alpha (T^A)^{1-\alpha}$. Similarly, we use (8) and (18) to calibrate z_1^B. We get $z_1^A = 1.64$ and $z_1^B = 17.0$.

Migration and slavery import: We estimate m by applying (2) to average decennial migration during AD1700-AD1770 (Table 5) and the AD1700 per capita income (Table 2); we found $m = 84{,}532$.[23] Similarly, from (13) and (14), $2fQ_t = w_t^A$. We use the average decennial slavery import during AD1700-AD1770 (Table 7) and the AD1700 per capita income (Table 2) to calibrate f; we obtain $f = 0.0000226$.

Population growth: We assume constant natural population growth rates in the two countries. For the Thirteen Colonies, applying the White population accumulation equation $L_8^H = \left(1+g^{L^H}\right)^7 L_1^H + M_8 + \left(1+g^{L^H}\right)M_7 + \cdots + \left(1+g^{L^H}\right)^6 M_2$ to AD1700-AD1770 data in Tables 4 and 5, we back out $g^{L^H} = 0.23$. Similarly, applying the Black population accumulation equation $L_8^F = \left(1+g^{L^F}\right)^7 L_1^F + Q_8 + \left(1+g^{L^F}\right)Q_7 + \cdots + \left(1+g^{L^F}\right)^6 Q_2$ to AD1700-AD1770 data in Tables 6 and 7, we obtain $g^{L^F} = 0.22$. For Britain, Maddison (2008) only provided population estimates for the United Kingdom and Ireland in AD1700 and AD1820, which are 8,565,000 and 21,239,000 respectively. Use $L_{13}^B = \left(1+g^{L^B}\right)^{12} L_1^B$ to get $g^{L^B} = 0.086$.

Income growth: For the Cobb-Douglas production function parameter, we follow Vollrath (2009) to set $\alpha = 0.4$. We calibrate the learning-by-doing parameter $\mu = 3.9 \times 10^{-8}$ to match per capita income growth trend in Britain, and the technology diffusion parameter $d = 0.03$ to match per capita income growth trend in the Thirteen Colonies (Figure 2B) during AD1700-AD1770.

Table 9 summarizes the benchmark parameters and initial values:

INSERT TABLE 9 HERE

Figure 4 (blue solid lines) depicts the benchmark simulation result. It shows the evolution of (a) per capita income in the Thirteen Colonies, (b) technology growth rate in the Thirteen Colonies $g_{t+1}^{z^A} \equiv \frac{z_{t+1}^A - z_t^A}{z_t^A}$, (c) White population share in the Thirteen Colonies, (d) number of White migrants to the Thirteen Colonies, (e) number of Black slaves imported to the Thirteen Colonies, and (f) per capita income in Britain during AD1700-AD1780. The (blue) dots indicate the data points implied from Tables 2-7.

INSERT FIGURE 4 HERE

Now we give an account of the development process in the Thirteen Colonies. Throughout AD1700-AD1780, there were faster technological progress and natural population growth in the

[23] Note that our Cobb-Douglas production function formulation implies that $w_t^A = \alpha y_t^A$ and $w_t^B = \alpha y_t^B$. Also, we use average decennial migration during AD1700-AD1770 instead of the decennial migration during AD1700-AD1710 to sort out the fluctuations in number of migrants during the eighteenth century.

Thirteen Colonies than in Britain.[24] The technology growth effect (proposition 1*(i)*) and natural population growth effect (proposition 2*(i), (ii)*) generate opposite forces and roughly offset each other, so that the numbers of migrants and slavery import stayed at roughly constant levels throughout AD1700-AD1780 (panels (d)-(e)). In the Thirteen Colonies, the transatlantic labor movement contributed to the gradual decline in White population share (panel (c)), exerting a negative population composition effect on technological progress (panel (b)).[25] Finally population dilution effect dominated the effect of technological progress, leading to per capita income decline throughout AD1700-AD1780 (panel (a)). In contrast, in Britain, technological progress was fast enough to make up for the population dilution effect, and hence per capita income gradually rose (panel (f)). Still, per capita income gap, and hence the wage gap, between the Thirteen Colonies and Britain was positive throughout AD1700-AD1780, inducing continuous migration from Britain to the Thirteen Colonies.

To summarize this section, we constructed a benchmark model that replicates demographic-economic development in the Thirteen Colonies during AD1700-AD1780 (arrows 2-3 in Figure 1).

5 THE EXTENDED MODEL (AD1700-AD1860)

We extend the benchmark model to study the importance of United States' land acquisition and slavery trade abolition on its development process up till AD1860.[26] In AD1776 the Thirteen Colonies broke away from the British Empire, and established the United States of America. The United States Constitution permitted free migration into and within the newly established Republic, and banned transatlantic slavery trade in AD1808 (Engerman and Margo 2011). Before the American Civil War in AD1861-AD1865, the United States was rapidly expanding its territories westwards.

5.1 United States Land Acquisition

Table 10 shows the total land area of the United States from AD1776 to AD1860.

INSERT TABLE 10 HERE

The three most significant United States land acquisitions during AD1776-AD1860 were the Treaty of Paris which marked the end of American Revolution in AD1783, the Louisiana Purchase from Napoleonic France in AD1803 and the Treaty of Guadalupe Hidalgo which concluded the Mexican-American War in AD1848. Since its independence, the United States has enlarged its

[24] From our simulation, technology level of the Thirteen Colonies grew by a factor of 3.5 during AD1700-AD1780, while in Britain technology level only grew by a factor of 1.5 during AD1700-AD1780. Together with $z_1^A = 1.64$ and $z_1^B = 17.0$, these validate our assumption that home technology was more advanced than colony technology within the simulation time frame (section 4.1.3).

[25] Otherwise, without transatlantic labor movement, the roughly same magnitude of g^{L^H} and g^{L^F} would not lead to a drop in White population share in the Thirteen Colonies.

[26] Engerman and Margo (2011, 310) suggested that "the best way to evaluate the impact of the Constitution and associated legislation is through general equilibrium analysis, possibly with a dynamic component".

land territories by 8.5 times its initial size by AD1860.

One of the most important features of United States land acquisition was that territory was expanded over sparsely-populated land. Turner's famous frontier thesis in AD1893 stressed this:

> "*The existence of an area of free land, its continuous recession, and the advance of American settlement westward, explain American development.*" (Turner 1976[1920], 1)

The frontier or free land refers to geographic regions with "a low man-land ratio and unusually abundant, unexploited, natural resources" (Billington 1966, 25).[27] While Turner (1976[1920])'s emphasis was on the role of frontier in promoting individualism, democracy and nationalism, ours is on the demographic-economic impact of such rapid increases in United States' natural resource base.[28]

For the demographic impact, theoretically, such land expansions would increase the marginal products of White and Black labor, encouraging White migration and Black slavery import to the United States. Proposition 3 states this result:

Proposition 3 (Land acquisition effect on migration and slavery trade): Ceteris paribus, land expansion in country A raises the numbers of migrants and slaves imported to country A, that is, $\frac{\partial M_t}{\partial T^A} > 0$ and $\frac{\partial Q_t}{\partial T^A} > 0$.

Proof: See Appendix 1.

For the economic impact, we extend the benchmark model in three dimensions. First, the new time frame spreads from AD1700 to AD1860, rather than from AD1700 to AD1780. Second, we include three periods of permanent "land shocks" to capture the three aforementioned United States land expansions: we assume the colony land area T^A to be raised by factors of $\frac{864,746}{349,250}$, $\frac{1,681,828}{864,746}$ and $\frac{2,940,042}{1,681,828}$ in AD1790, AD1810 and AD1850 respectively. Third, we modify the technological progress equations (15) and (16) by adding a quadratic learning-by-doing term to capture the acceleration of British per capita income growth during the early-nineteenth century (British Industrial Revolution):

$$z_{t+1}^B = z_t^B + \mu_1 Y_t^B + \mu_2 (Y_t^B)^2 \ , \ \mu_1, \mu_2 > 0 \ , \tag{19}$$

$$z_{t+1}^A = z_t^A + \frac{L_t^H}{L_t^A} \cdot [\mu_1 Y_t^A + \mu_2 (Y_t^A)^2 + d(z_t^B - z_t^A)] \ , \quad \mu_1, \mu_2, d > 0 \ . \tag{20}$$

Note (20) implicitly assumes that the Black population still did not have incentive to learn and improve work till the eve of the American Civil War.[29] We recalibrate μ_1, μ_2 and d to match

[27] Turner (1976[1920], 3) emphasized that the "most significant thing about the American frontier is, that it lies at the hither edge of free land … which has a density of two or more [settlement] to the square mile".

[28] Findlay and Lundahl (1994, 70) and Barbier (2011, xiv) noted that, the analysis of frontier-based development "has been used extensively by historians and geographers for a wide variety of times and places, but has been neglected by economists."

[29] Even though the northern states in the United States had abolished slavery by AD1804, Litwack (1961, 15) stated that, until the post-Civil War era, the public minds in both US-North and US-South continued to "[hold] conviction that the African race was inferior" and discriminated against the Blacks "politically, socially, and most certainly physically". We make the extreme assumption that the Blacks were still not incentivized to improve their work before AD1860, to

per capita income growth trends in Britain and in the Thirteen Colonies/United States during AD1700-AD1860. Table 11 summarizes the parameters and initial conditions that we will use in this subsection.

INSERT TABLE 11 HERE

Figure 5 depicts the simulated development paths of the Thirteen Colonies/United States with land acquisition (red dashed lines, parameters from Table 11) and without so (blue solid lines) during AD1700-AD1860. As proposition 3 predicts, the United States land acquisition during AD1776-AD1860 raised the numbers of British migrants (panel (d)) and imported African slaves (panel (e)) when compared to the benchmark case.[30] Through a production scale effect on technological progress (panel (b)), the United States grew along a superior per capita income path (panel (a)).

INSERT FIGURE 5 HERE

The above results rely on the "free land" assumption. In our model, if the newly acquired lands had instead been densely-populated with native Indians and the United States had treated them like African slaves, then the United States would not have grown as fast as it had in the "free land" case. The counterfactual experiment (green dotted lines) in Figure 5 illustrates this: we rerun the extended model using parameters from Table 11, with an additional assumption that the Black population size would increase exogenously by the same proportions as land area expanded during the three land shock periods (AD1790, AD1810 and AD1850). Per capita income would rise more slowly in this case (panel (a)) due to the adverse population composition effect on technological progress (panel (b)), as well as the population dilution effect on per capita income.

The above exercises illustrate that geography and population matter in accounting for American economic growth. It was the "free land" abundance that allowed the United States to outpour its population across the continent, and take advantage of production scale effect on technological progress. Although our simulation stops in AD1860, it is not difficult to realize that this type of economies of scale would eventually allow the United States to overtake and retain its technological lead over Britain.[31] This is reflected in Wolff (1991, 568)'s total factor productivity estimates, where the United States overtook Britain in the AD1900s and has retained its lead thereafter.

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simplify our analysis.

[30] However, one fact that our model (Figure 5, panel (d)) fails to reproduce is the continuous rise in migration from the British Isles to the United States since the AD1820s, in particular the sharp increase during the AD1840s and AD1850s (U.S. Bureau of the Census 1975, series C89-119). The long-term rise originated from transatlantic transportation improvement, while the sharp increase during the AD1840s and AD1850s was likely to be caused by deteriorating economic conditions in Europe due to the potato famines (Haines 2000, 197-198).

[31] We conjecture that similar reasoning applies to Australia and Canada, two other "Great Frontier[s]" in world history (Webb 1952, 10), which retained their aggregate productivity lead over Britain since the AD1860s and AD1950s (Broadberry and Irwin 2007, 267; Wolff 1991, 568). To explain the lack of good economic outcomes in Latin American countries which also possessed frontiers in the nineteenth century, García-Jimeno and Robinson (2011, 53) proposed the "conditional frontier thesis", which states that the impact of the frontier are conditional on the existing political institutions. They found evidence for the thesis using economic and political data from 21 American countries.

5.2 United States Slavery Trade Abolition

We next investigate the impact of slavery trade abolition. The United States Congress began to regulate slavery trade in AD1794. In AD1800, it dramatically raised fines for illegal citizen participation in slavery trade, and awarded the officers and crews who made the slavery trade seizure the right to the value of the vessel. In AD1803, new fines were introduced for people who brought slaves or any "negro, mulatto, or other person of color" into states that banned slave importation. In AD1807, the Congress passed the Act Prohibiting Importation of Slaves, where fines and imprisonment were raised to high enough levels that discouraged most slave smugglers (Finkelman 2012, 120-121). In terms of our model, these raised the slavery trade cost parameter f. Proposition 4 states how an increase in slavery trade cost parameter affects transatlantic migration and slavery trade.

Proposition 4 (Slavery-trade-cost-increase effect on migration and slavery trade): Ceteris paribus, an increase in slavery trade cost parameter raises the number of migrants and reduces the number of slaves imported to country A, that is, $\frac{\partial M_t}{\partial f} > 0$ and $\frac{\partial Q_t}{\partial f} < 0$.

Proof: See Appendix 1.

Theoretically, the increase in slavery trade cost parameter f reduces slavery import. This will increase marginal product of White labor and hence their wage in the colony (when compared to the case of no rise in f), thereby attracting more White migration to the colony.

We extend the model in section 5.1 to study the demographic-economic impact of the Prohibiting Act. Consider an exogenous rise of slavery trade cost parameter f to a prohibitively-high level $f = 1$ from AD1810 onwards, to reflect the implementation of the Prohibiting Act. Table 12 shows the parameters and initial conditions we employ in this subsection.

INSERT TABLE 12 HERE

Figure 6 depicts the simulated development paths of the Thirteen Colonies/United States with slavery trade abolition (red dashed lines, parameters from Table 12) and without abolition (blue solid line, parameters from Table 11) during AD1700-AD1860. For the demographic impact, after the Prohibiting Act was established, slaves flowing into the United States dropped to zero by construction (panel (d)). However, the responding increase in White migration was quite modest (panel (c)). The number of White migrants followed pretty much the same path with or without slavery trade abolition.

INSERT FIGURE 6 HERE

Similarly, for the economic impact, the Prohibiting Act did not have a significant impact on subsequent per capita income growth (panel (a)). The reason was that the positive population composition effect on technological progress, originating from a smaller Black population share, was nullified by the negative production scale effect on technological progress caused by the smaller total labor input in the United States (panel (b)). Hence slavery trade abolition happened to occur in the United States history at a time when its main developmental impact was to slow down the Black population stockpile.[32]

[32] Our model does not capture one effect of slavery trade abolition: expecting the Congress to

To summarize this section, we examined the impacts of land acquisition and slavery trade abolition on development process in the United States. The two cases also illustrated how geography and policy affected economic outcomes through the population channel (arrows 1-2 in Figure 1). We refer to the calibrated model in this subsection (Table 12) as the Extended Model. Now we are ready to tackle the divergence issues (reversal of fortune) within the United States and across American countries.

6 REVERSAL OF FORTUNE WITHIN THE UNITED STATES

In section 6.1 we simulate the demographic-economic evolution in US-North and US-South during AD1700-AD1860. In section 6.2 we put forward the GeoPopulation-Institution hypothesis to explain the reversal of fortune between the two regions.

6.1 Simulation: US-North and US-South AD1700-AD1860

To apply the Extended Model to US-North (with subscript *N*) and US-South (with subscript *S*), we consider the world economy consisting of three regions/countries: US-North, US-South and Britain, the former two being American colonies of Britain.[33] Assume there is no inter-colonial migration between US-North and US-South, then we can directly apply the Extended Model to the two pairs of home-colony dyads: Britain-US-North and Britain-US-South. We modify (20) as:

$$z_{t+1}^A = z_t^A + \left(\frac{L_t^H}{L_t^A}\right)^3 \cdot [\mu_1 Y_t^A + \mu_2 (Y_t^A)^2 + d(z_t^B - z_t^A)] \ , \quad \mu_1, \mu_2, d > 0 \ , \tag{21}$$

in this subsection. The White population share term $\frac{L_t^H}{L_t^A}$ is raised to the third power. This strengthens the population composition effect on technological progress, which is required to reconcile the divergence of per capita income between US-North and US-South in AD1840 (Figure 2A, Figure 7 panel (a)). The calibration procedures are similar to those in section 4.3 and we leave it in Appendix 3. Table 13 displays the calibrated parameters and initial conditions.

INSERT TABLE 13 HERE

Inspecting Table 13, the most important structural differences between US-North and US-South lie in the divergence of natural population growth rates ($g^{L^{HN}} = 0.29$, $g^{L^{FN}} = 0.24$ and $g^{L^{HS}} = 0.15$, $g^{L^{FS}} = 0.21$), British willingness to migrate ($m^N = 369{,}048$ versus $m^S = 18{,}870$) and slavery trade cost parameter ($f^N = 0.000436$ versus $f^S = 0.0000402$).

Figure 7 depicts the simulated development paths for US-North (blue solid lines) and US-South (red dashed line) during AD1700-AD1860, with the (blue) dots and (red) crosses

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prohibit international importation of slaves, slave traders might have increased slavery imports and driven up slave prices before the Prohibiting Act was implemented in AD1807 (Mancall et al. 2001; Engerman and Margo 2011).

[33] Before AD1780, the definitions of US-North and US-South follow from Table 4. After AD1780, we assume that the land areas of US-North and US-South would be enlarged by the same factors as the total land area of the United States did in Table 10.

representing their respective data points implied from Tables 2-7. US-South was initially more prosperous than US-North (panel (a)), thanks to its higher starting productivity. Despite the higher starting wages in US-South, the higher British willingness to migrate to US-North translated into a roughly parity in numbers of British migrants to US-North and to US-South in the eighteenth century, as well as a greater number of British migrants to US-North in the early-nineteenth century (panel (d)). At the same time, the higher slavery trade cost parameter in US-North prior to AD1810 discouraged the import of African slaves to US-North (panel (e)). Consequently, the White population share was in general rising in US-North and falling in US-South (panel (c)). Through population composition effect on technological progress, US-North enjoyed a faster technology growth during AD1700-AD1860 (panel (b)), allowing it to overtake US-South in terms of per capita income level in around AD1820 (panel (a)).

INSERT FIGURE 7 HERE

After the overtake, US-South was still suffering from slow technology growth due to its persistently low White population share (panel (c)), and its per capita income was stagnating in the remaining simulation periods. In contrast, per capita income growth in US-North had gained momentum well into AD1860, thanks to its high White population share which was conducive to technological progress (panel (b)).

Our next question is what accounts for the three structural parameter differences (lower g^{L^H}, g^{L^F}, m, f in US-South), which in turn explains the divergence between US-North and US-South. More generally, these parameter differences will also show up in another group of American countries that suffered from relative economic decline (West Indies in section 7.1). We argue that, accounting for these differences is crucial to the understanding of reversal of fortune in American economic history. In the next subsection we propose the GeoPopulation-Institution hypothesis to provide an explanation.

6.2 The GeoPopulation-Institution Hypothesis

The *GeoPopulation-Institution hypothesis*, as its name suggests, highlights the interplay among geography, population and institution in explaining American development and divergence during the colonization era (Figure 1). The core content of the hypothesis is that, whenever its geographic or political environments relatively favored the buildup of Black slaves (or more generally, non-White forced labor), through slavery institution that disincentivized the Blacks to make improvements, an American region/country was likely to be cursed by the reversal of fortune. From our calibration in the previous subsection, the region being cursed by the reversal of fortune (US-South) possessed low natural population growth rates ($g^{L^{HS}}$, $g^{L^{FS}} < g^{L^{HN}}$, $g^{L^{FN}}$), low European willingness to migrate ($m^S < m^N$) and low slavery trade cost parameter ($f^S < f^N$). We will argue how the GeoPopulation-Institution hypothesis explains these parameter differences.

Figure 8 depicts the breakdown of GeoPopulation-Institution hypothesis, which can be split into three components: the geography channel, the population channel and the institution channel.

INSERT FIGURE 8 HERE

For the geography channel, disease environment, soil and climate suitability for growing staple crops affected mortalities and life expectancies, generating different degrees of attractiveness to potential European settlers and the use of African slaves among American

regions/countries. The warm and humid climate of US-South was hospitable to malaria, yellow fever and hookworm, continuing to threaten the local health environment (Savitt and Young 1988, ch.2-4; McCandless 2011, ch.3). Making the health problem worse in the lowcountry area was that the factor endowments there fostered rice cultivation, putting laborers to work under a rigorous regime (Galenson 1981b, 154-156). These made US-South an unhealthy place, as reflected by the shorter life expectancies when compared to US-North (Table A.1). Hence US-South possessed a slower natural population growth ($g^{L^{HS}}$, $g^{L^{FS}} < g^{L^{HN}}$, $g^{L^{FN}}$) and discouraged Europeans from immigrating ($m^S < m^N$). On the other hand, the Africans "had developed better biological defenses against the troublesome parasites" (Rutman and Rutman 1976, 35; Silver 1990, 160), making them an attractive labor choice in the plantation complex in US-South ($f^S < f^N$).[34] Summarizing this channel, low natural population growth rates would be associated with low European willingness to migrate and small slavery trade cost parameter.

For the population channel, corresponding to the willingness of European migration and the use of slaves created by the geography channel, as well as domestic labor scarcity and political environment, transatlantic migration and slavery trade took place and shaped the demographic process. In US-North, the "hostility" of White labors rendered the use of Black slaves "unprofitable" ($f^S < f^N$) (Litwack 1961, 6). Taking European willingness to migrate (m^N, m^S), slavery trade cost parameter (f^N, f^S) and domestic labor scarcity into account, colonial producers would make decisions on White labor hiring and Black slavery import to maximize their rents, altering population size and composition in the colonies (sections 4.1.1 and 4.1.2). Colonial producers would import more African slaves if White labors were scarce, or if it was less costly to import African slaves.[35] That means, low European willingness to migrate and low slavery trade cost parameter would lead to the relative buildup of Black slaves in US-South. By the eve of the American Revolution, these turned US-South into a settlement region characterized by a higher Black population share (Table 6). In addition, two geographic factors – initial productivity (z_1^{AN}, z_1^{AS}) and land abundance (T^{AN}, T^{AS}) would also contribute to population evolution.[36] Ceteris paribus, the higher initial productivity or the larger land area was, the more Europeans migrating for the higher colony wage and slaves being imported by the colonial producer would be; this speeded up the population stockpile.

For the institution channel, the change in White-Black population mix would affect economic growth through the population composition effect on technological progress (section 4.1.3). The slavery institution deprived the Blacks from the rights to property and choice of work, and disincentivized them from learning, innovating and making improvements (Smith 1994[1776];

[34] This might also be one reason contributing to the higher Black natural population growth rate than the White's in US-South in Table 13. In contrast, in US-North, the winters there might have been "unfavourable to the African constitution", making the Whites a preferred labor choice to the Blacks (Litwack 1961, 4).

[35] Galenson (1981b, 149-156; 1984) stated that, from the mid-seventeenth to eighteenth centuries, facing the short supply and rising relative price of English servants, colonial planters in West Indies, the Chesapeake, South Carolina, and Georgia turned from White servants to Black slaves as the primary source of bound labor.

[36] Before American industrialization, productivity mainly refers to whether the land could grow valuable crops for sale. For example, US-South was blessed with fertile soil, long, warm and humid summers, making it suitable for growing cash crops (tobacco, rice, indigo, cotton, etc.).

Emerson 1884; Fogel and Engerman 1989; Acemoglu and Roberson 2012). In contrast, White labors, who usually came in the form of indentured servants, retained basic legal rights during the indenture period and were set free after the indenture expired (section 3.1.2). The wage the free Whites earned would encourage them to propagate their work.[37] Therefore the greater the Black population share was, the slower technological progress would be. The relative buildup of Black slaves in US-South was detrimental to economic progress in the long run and eventually caused the region's relative decline.

We emphasize again, in our GeoPopulation-Institution hypothesis, that natural geography, population structure and slavery institution are integrated components in explaining development and divergence in the United States (sections 4.3, 5 and 6). Without geography, we could explain neither the relative growth of the Black population in US-South (disease environment and soil/climate suitability for staple crops) nor the United States eventually overtaking Britain in terms of technology and economy (resource abundance in the United States). Without slavery institution, we could not account for the reversal of fortune between US-North and US-South (disincentivized Blacks in learning and improving). The population channel provides one key linkage through which geography and institution interact to foster American development and divergence during the colonization era. In our model, geographical differences and slavery institution are both exogenous, and population evolution illustrates one channel by which geography could affect economic growth. This channel has not been considered in Acemoglu et al. (2001) and Rodrik et al. (2004)'s instructmental regression analyses (section 2.1), which might pose issues on their instrument exogeneity assumptions and the conclusions derived from them.[38]

To summarize this section, our unified growth model simulated demographic-economic evolution in US-North and US-South, and replicated the reversal of fortune between the two regions. We proposed the GeoPopulation-Institution hypothesis to account for the calibration results.

7 REVERSAL OF FORTUNE ACROSS AMERICAN COUNTRIES

In this section we illustrate how the unified growth model and the GeoPopulation-Institution hypothesis reconcile the decline of the once prosperous Portuguese-type sugar-exporting countries (section 7.1) and Spanish-type resource-exploitation countries (section 7.2) relative to United-States-type White-populated countries (section 7.3).

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[37] Adam Smith (1994[1776], 93) stated that, "[t]he liberal reward of labour, as it encourages the propagation, so it increases the industry of the common people. The wages of labour are the encouragement of industry, which, like every other human quality, improves in proportion to the encouragement it receives."

[38] Acemoglu et al. (2001, 1378) posited the following regression model to estimate the effect of current institutions on current per capita income (β):

$$current\ per\ capita\ income = \beta \cdot current\ institutions + controls + error\ .$$

They employed *settler mortality* as an instrument for *current institutions*, and performed two stage least square regressions. For *settler mortality* to be a valid instrument for *current institutions*, it should not affect *current per capita income* through channels other than its effect on *current institutions*. However our GeoPopulation-Institution hypothesis now suggests one such channel.

7.1 Portuguese-type Sugar-exporting countries

Portugal began to develop sugar industry in Brazil since the AD1520s. Sugar plantation operated with a large scale of labor force. In Brazil, on average each *engenho* (sugar plantation with mills) had about 100 slaves. Initially the industry relied on local Indian labor supply. Since the AD1570s, facing continuing Indian resistance, spread of plagues that reduced the Indian population, as well as the Crown and Church's opposition to the enslavement of Indians, Portugal increased its reliance on African slaves to supply labor in Brazil. By the AD1600s Black slaves became the dominant labor force (Schwartz 1978; Galloway 1989, ch.4). Soon Brazil became the leading world sugar exporter, blessing its northeast part as one of the most prosperous regions in the world. However by the close of the seventeenth century, the centers of sugar production had shifted to the Caribbean islands and Brazil stagnated (Edel 1969).

Since the AD1620s Britain, France and the Netherlands began to seize the Caribbean islands from the Spanish Empire. The Sugar Revolution in Barbados in the AD1640s raised expectations of sugar profit, and these European powers quickly converted their Caribbean Antilles to sugar production areas. Due to their closer proximity to European and North American markets, these islands became very wealthy and prosperous (Higman 1996, 301; Gomez-Galvarriato 2006; Maddison 2007, ch.2); they were among the richest regions in America in the AD1700s (Table 8). The Caribbean islands were so prosperous and strategically important that they have been described as "the pawn of European power politics, the cockpit of Europe, the arena of Europe's wars hot and cold" (Williams 1970, 69). However, the relative prosperity of West Indies did not last into the nineteenth century. The United States and Canada had overtaken them by AD1820. What accounted for the relative decline of the cockpit of Europe?

Similar to section 6, we first calibrate our unified growth model (Extended Model) to the West Indies data, and reveal its parameter differences when compared to the Thirteen Colonies/United States. For land area, we sum total land area of the islands being identified as "West Indies" in Table 4, provide by CIA (2016). For initial per capita income, in AD1700 West Indies was $\frac{650}{527}$ times wealthier than the future United States (Table 8). We set West Indies and the Thirteen Colonies/United States' AD1700 initial per capita incomes to $\frac{650}{527} \times 3.45 = 4.26$ and 3.45 respectively. The other parameters are calibrated in similar fashions as those in Appendix 3. Table 14 shows the calibration results.[39]

INSERT TABLE 14 HERE

Comparing the calibrated parameters in West Indies and in the Thirteen Colonies/United States, the structural differences are the poorer demographic performance in West Indies (negative g^{LH} and g^{LF} in West Indies versus positive g^{LH} and g^{LF} in the other), the lower European willingness to migrate to West Indies ($m = 35{,}096$ in West Indies versus $m = 84{,}532$ in the other) and the smaller slavery trade cost parameter in West Indies ($f = 0.00000781$ in West

[39] Note that the parameter values in the Thirteen Colonies/United States panel in Table 14 are identical to those in Table 12.

Indies versus $f = 0.0000226$ in the other).

Figure 9 depicts the simulated development paths for the Thirteen Colonies/United States (blue solid lines) and West Indies (red dashed lines) during AD1700-AD1860. Reversal of fortune between the two regions occurred by AD1790 (panel (a)). Before that, the higher productivity level in West Indies made it a wealthier region. However, the lower European willingness to migrate and the smaller slavery trade cost parameter in the West Indies maintained the high Black population share in the sugar Antilles (panel (c)). Due to its smaller production scale and less conducive population composition to technological progress (panel (b)), the West Indies was eventually surpassed by the United States. Since then the originally blooming Antilles has fallen from its past prosperous grace.[40]

INSERT FIGURE 9 HERE

Now we apply the GeoPopulation-Institution hypothesis (Figure 8) to account for the "lower g^{L^H}, g^{L^F}, m, f" in West Indies. First, for the geography channel, diseases such as malaria, yellow fever, tetanus and dysentery were more prevalent and virulent in tropical climates than in temperate ones, turning West Indies into a "demographic disaster area" (Fogel and Engerman 1989, 26; Dunn 1972, 334). Also, the combination of fertile soil and tropical climate in West Indies favored cane sugar cultivation (Sheridan 2000[1974], 14), which was characterized by high fixed capital requirement and efficiently operated under the gang labor system. The high mortality rates and tough working conditions under the gang system made Europeans avoid this region (Galenson 1981b, 150-151; 1984).[41] For political environment, prior to AD1783, Williams (1964, 39) mentioned that, "all classes in English society … in general, supported the slave trade". The above explains the parameter differences between West Indies and the Thirteen Colonies/United States. Similar to the US-South case in section 6.2, it was in the colonial producers' (absentee proprietors) interest to rely on African slavery as the dominant source of labor to maximize their land rents. Through the population composition effect, this hindered technological progress in the West Indies, leading to its relative economic decline. Note that one geographic factor that also contributed to the rapid rise of the United States income since the turn of the nineteenth century was its fast territorial expansion (section 5.1), expediting its technological progress through the production scale effect.

To summarize, for Portuguese-type countries, their favorable soils and climates for sugar plantation brought them immediately blooming economies during the seventeenth and eighteenth centuries. However sugar also turned them into slave-based economies, harming their growth capabilities. Reversal of fortune eventually occurred.

7.2 Spanish-type Resource-exploitation countries

[40] There were two events accentuating the decline of West Indies in the nineteenth century. The first was the expansion of sugar beet production since the Continental Blockade by Napoleonic France, which had a depressing effect on cane sugar price. The second was the abolition movements, making labor shortage an issue to colonial planters; some reduced the acreage of cane production in response (Galloway 1989, 123-125, 130-131, 145-147).

[41] Adam Smith (1994[1776], 633) stated that the Europeans "could not, it is supposed, support the labour of digging the ground under the burning sun of the West Indies", so the culture of sugar-cane was carried on by negro slaves.

Spain's colonial interest lied in resource exploitation. Being the first Europeans to arrive in America (West of the Papal Line), Spain decided to center its activities on Central America and Andean region, areas with dense native population and rich mineral deposits. Mining, and to a lesser extent commercial agriculture, were the dominant economic activities in Spanish America (Newson 2006, 170-171). An important feature of Spanish colonial rule was stringent European migration restrictions to the New World.[42] The reasons for such restrictions were to keep defense costs down, as well as to maintain the privileged position of the elites who had made the move earlier (Engerman and Sokoloff 1997, 2000; 2012, ch.7).[43] The restrictions made the White population contribute to only a small proportion of labor supply in Spanish colonies. In the core areas of Spanish America (Mexico and Andes), where large numbers of native Indians were available, Spain could obtain sufficient forced domestic labor through *encomienda* and later *repartimiento* (Newson 1985, 1993).[44] *Encomienda* was a labor system where Spanish settlers were granted the rights to extract labor or tribute from Indian populations. In AD1549, *encomienda* was replaced by *repartimiento*, an essentially compulsory wage labor system for Indians, requiring indigenous communities to meet working quotas with wages set well below the free-market levels (Monteiro 2006, 199-200; Allen et al. 2012). In the peripheral areas which were largely depopulated, Spain relied on African slaves to make up for the shortages of labor (Klein and Vinson III 2007, 20-21).

Similar to slavery, Spanish colonial labor market institutions (*encomienda* and *repartimiento*) placed Indian workers under exploitation.[45] This discouraged them from learning and making improvements.[46] In terms of our unified growth model, country A and country B are Spain and its American colony respectively. Now we identify L_F as non-White population (Indians or Africans) size in the colony, Q_t as slavery (non-White forced labor) import into the colony.[47] The Spanish migration restriction policy maintained a high proportion of non-White population in its colonial empire. Proposition 5 states how the numbers of migrants and imported slaves (non-White forced labor) would be affected by strengthening migration restrictions, which is

[42] Landes (1998, 311) stated that, "the crown did its best to keep these [European] outsiders away from its possessions in the New World." Jacobs (1991, 68-69) made a comparison between wages in Castile/Andalusia and travel expenses to Tierra Firme in the AD1600s, and concluded that savings from wages alone would not be sufficient to finance emigration to the New World.

[43] Engerman and Sokoloff (2012, 218) stated that, "the Crown began early in the sixteenth century to regulate and restrict the flow of European migrants to its colonies in the Americas. The stringency of the limits did vary somewhat over time, … but overall there is no doubt that Spanish policies limited, rather than encouraged, the migration of Europeans to the New World."

[44] Even well into the turn of the nineteenth century, Spanish colonies (Mexico, Peru and Chile) were still characterized by high proportions of Indians, rather than Whites and Blacks (Table 1).

[45] In practice, *encomienda* and slavery differed in that the Spanish Crown imposed inheritance, trading and relocation restrictions on *encomenderos* (Yeager 1995). Also, *encomienda* was by intention benevolent: the Spanish settlers who were granted *encomienda* were supposed to provide for protection, conversion and civilization of the aborigines (Bolton 1917).

[46] Newson (2006, 175) stated that, under *encomienda* and *repartimiento*, "there was no incentive for [the Indian workers] to preserve the labor force or develop its skills."

[47] We take "non-White forced labor import" as Indian and African labor supply that Spain could obtain outside the natural increased amount within its colonial boundary. Historically, Spain extended Indian labor supply through missionary work and enslavement (Newson 1985, 1993), and it imported African slaves through transatlantic slavery trade (Klein and Vinson III 2007, ch.2).

modeled as an exogenous reduction in m in our model.

Proposition 5 (Migration-restriction effect on migration and slavery trade): Ceteris paribus, given that the wage in country A is higher than the wage in country B, a tightening of migration restriction to move to country A reduces the number of migrants and raises the number of slaves (non-White forced labor) imported to country A, that is, $\frac{\partial M_t}{\partial m} > 0$ and $\frac{\partial Q_t}{\partial m} < 0$, given $w_t^A > w_t^B$.

Proof: See Appendix 1.

Tightening migration restrictions leads to more labor scarcity and raises marginal product of labor in the colony. The colonial producer would raise slavery (non-White forced labor) import to maximize the land rent he or she could extract from the colony's production activities.

We illustrate how the Spanish migration restriction policy maintained the low White population share, and led to relative economic decline in the Spanish colony. Table 15 shows the parameter values for a "US-type country" and a "Spanish-type country" for illustration purpose. We set most of the parameter values for the two countries to be the same as those in Table 11. There are no land acquisition and slavery trade abolition, so that we can focus on the effect of Spanish migration restriction policy. The only differences between the two countries lie in the parameter value m, initial White population share and initial technology level. From Eltis (2000, 9), during AD1700-AD1760, the numbers of Europeans migrating to the New World were 193,000 for Spain and 372,000 for Britain respectively. We simply set m in "Spanish-type country" to be a fraction $\frac{193{,}000}{372{,}000}$ of m in "US-type country". We obtain m in "Spanish-type country" as 43,857. We attribute the lower willingness to migrate to "Spanish-type country" to the migration restrictions in the Spanish colony. We set the initial White population share in the "Spanish-type country" to Easterly and Levine (2015)'s Euro share estimate in AD1650 Mexico (5.26%).[48] For initial per capita income, in AD1700 Mexico was $\frac{755}{527}$ times wealthier than the future United States (Table 8). We calibrate z_1^A in "Spanish-type country" to 2.35 to match this fact.

INSERT TABLE 15 HERE

Figure 10 depicts the simulated development paths for the "US-type country" (blue solid line) and the "Spanish-type country" (red dashed line) during AD1700-AD1860. The migration restriction policy kept the White population share low in the "Spanish-type country" (panel (c)), cursing it with slow technological progress (panel (b)). Eventually reversal of fortune occurred in around AD1760 (panel (a)).

INSERT FIGURE 10 HERE

The GeoPopulation-Institution hypothesis offers a deep explanation for the relative decline of Spanish-type countries. Geographically, the initially dense indigenous populations and

[48] Easterly and Levine (2015) provided Euro share estimates in AD1551 El Salvador, AD1572 Guatemala, AD1650 Argentina, Bolivia, Chile, Colombia, Ecuador, Mexico, Paraguay, Peru and Venezuela, AD1700 Costa Rica, Cuba and Dominican Republic, AD1750 Puerto Rico, AD1778 Panama and AD1786 Honduras. Except Cuba, Dominican Republic, Panama and Puerto Rico, all Euro shares were less than 20%

precious metal mines in Central America and Andean region attracted Spanish conquest (Lockhart and Schwartz 1983, 84-85; Arroyo Abad et al. 2012). In the conquered colonies, labor scarcity problem, aggravated by the Spanish migration restriction policy, had fostered the exploitation of native Indians and African slaves (Elliott 2006, 99) through *encomienda* and *repartimiento*, as well as African slavery. Those were forced labor systems that discouraged the vast non-White population to contribute to economic progress, leading to the relative decline of Spanish-type countries in the centuries to come.

7.3 United-States-type White-populated countries

For the United States and Canada, there were neither dense indigenous populations nor rich mineral deposits to exploit at the outset of the colonization era. The soils and climates in general favored regimes of mixed farming that centered on grains and livestock, instead of sugar which required an enormous amount of plantation workers (Engerman and Sokoloff 1997, 2000; 2013, 68). Hence there was little incentive for the colonial producers (or European powers) to import African slaves (or impose coercive labor systems on domestic population).[49] As a result, these countries possessed high proportions of European descendants (Table 1), who were free from forced labor institutions and conducive to technological progress and economic growth. Eventually, the United States and Canada turned into the richest American nations in the early-nineteenth century (Table 8).

8 DISCUSSION

8.1 Geography-Population-Institution

The central theme of this paper is to argue that geography, population and institution are united components in orchestrating the rise and fall of nations in American landscapes during the colonization era. Geographic factors (disease environment, soils and climates, resource abundance, territory expansion), population structure (White, Black and Indian labor) and labor market institutions (slavery institution, overseas slavery trade abolition, migration restriction, forced labor systems) are inseparable elements in explaining American economic history.[50] Our unified growth model and GeoPopulation-Institution hypothesis reconcile (early-United States) development and (within-United States or across-nation) reversal of fortune that has occurred in the Western Hemisphere.

In our theory, the population composition effect on technological progress provides the

[49] Elliott (2006, 103) stated that, when compared to the Providence Island, in New England "the combination of a good supply of immigrants with high survival and reproductive rates, the absence of a staple crop, and the widespread use of family labour, all reduced the necessity for importing slaves."

[50] The view to take geography, population and institution simultaneously into account in explaining economic progress can be traced back at least to Adam Smith (1994[1776], 410):

> "*Had human institutions, therefore, never disturbed the natural course of things, the progressive wealth and increase of the towns would, in every political society, be consequential, and in proportion to the improvement and cultivation of the territory or country*."

crucial link between geography and institution to account for the growth of American regions/countries. Our theory does not claim that the Black people were by themselves burden for economic growth. Indeed, the slavery institution that dissipated liberal returns to Blacks' labor was the crux to this effect.[51] More generally, social stratification, either politically, economically, socially or culturally, can have implications on actual or perceived discrimination, affecting a country's ability to engage in technological or organizational progress (Bénabou 2005), or even threatening national security (Gurr 1993).[52] Taking this into account in designing incentive systems to promote learning and propagation would be important for nations to realize their full growth potentials.

8.2 The Great Divergence among American countries: AD1870-AD2008

Our theory also has implications on the post-AD1860s Great Divergence among American countries. One crucial component of our theory is legal asymmetry between the Whites and the Blacks during the colonization era. The implication is that, after the abolition of slavery institution, the population composition effect on technological progress would fade away, and production scale effect and technology diffusion effect would then dominate. This in turn implies that, holding population growth rate across American countries constant, once the country with the largest production scale becomes the richest country, it will perpetually retain its per capita income lead.[53] Reversal of fortune will not occur thereafter.

This prediction fits the growth experience among American countries since the late-nineteenth century, when most of them had abolished slavery institution.[54] Figure 11 plots log per capita income in AD2008 against log per capita income in AD1870 among 13 American countries where we have data from Bolt and van Zanden (2013).[55] In contrast to Figure 3, there was no trend of reversal of fortune – indeed, countries with higher per capita income in AD1870 in general continued to remain so in AD2008. The early Great Divergence pattern among American countries emerged by AD1870 persists into today. In other words, history dependence of economic prosperity ("Persistence of fortune") has become a feature among American countries

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[51] Williams (1964, 7) stated that, "[s]lavery was not born of racism: rather, racism was the consequence of slavery."

[52] Societies being stratified by income, power, age, gender, race and ethnicity, and so on, is a never-ending issue. Marx and Engels (1910[1848], 12) put, "[t]he history of all hitherto existing society is the history of class struggles." They reviewed how the capitalist class displaced the feudal aristocracy as the supreme class in the modern society, and predicted that the capitalist exploitation of workers would lead to social revolutions that overthrow the capitalist system itself.

[53] In reality, the fading of population composition effect might take a long time. For example, in the United States, slavery institution was abolished in AD1865 (Thirteenth Amendment to the United States Constitution), but equal opportunities to race were legislated nearly a century later (The Civil Rights Act of 1964).

[54] Fogel and Engerman (1989, 33-34) provided a chronology of American slavery abolition: Haiti (1804), Argentina (1813[1853]), Colombia (1814[1851]), Chile (1823), Central America (1824), Mexico (1829), Bolivia (1831), British colonies (1838), Uruguay (1842), French and Danish colonies (1848), Ecuador (1851), Peru and Venezuela (1854), Dutch colonies (1863), the United States (1865), Puerto Rico (1873), Cuba (1886) and Brazil (1888).

[55] Our sample includes 13 countries, namely Argentina (AR), Brazil (BR), Canada (CA), Chile (CL), Colombia (CO), Cuba (CU), Ecuador (EC), Jamaica (JM), Mexico (MX), Peru (PE), the United States (US), Uruguay (UY) and Venezuela (VE).

since the late-nineteenth century.[56]

INSERT FIGURE 11 HERE

8.3 Three groups of American countries: Endogenous population versus Endogenous institution

When we analyze reversal of fortune among American countries (sections 3.2 and 7), we categorize the American countries into three groups - Spanish-type resource-exploitation countries, Portuguese-type sugar-exporting countries and United-States-type White-populated countries. Our categorization echoes the three groups of American countries highlighted by Engerman and Sokoloff (1997, 2000). They stated that, due to the elite-tilting policies in Spanish-type countries and the high-use of slaves in Portuguese-type countries, high within-country inequalities in wealth, human capital and political power were generated. This would then lead to institutions towards maintaining the inequalities, that have adverse impacts on the evolution of markets, commerce and technology. Therefore these two groups of countries fell behind the United States and Canada in terms of economic growth since the eighteenth century.

In their argument, the crucial link between factor endowments and differential economic development is within-country inequalities and endogenous institutions. In comparison, in our theory, the critical linkage between geographic factors and divergent income growth paths lies in transatlantic labor movement and endogenous population structures. The two theories are likely to be complementary in explaining reversal of fortune among American countries. For example, a higher inequality within an American country might discourage European migration, and the colonial planters would turn to slavery import to resolve the labor scarcity problem. This would accentuate the adverse population composition effect on technological progress, therefore accelerating the reversal of fortune among American countries during the colonization era.

8.4 Resource blessing versus Resource Curse

In our model, whether resource was a blessing or a curse (section 2.1) for the American economies during the colonization era depends on whether resource boost would lead to a population structure that was conducive to growth. For example, the Sugar Revolution in Barbados in the AD1640s opened up the prosperity of West Indies' land in planting sugar. However, the rise of sugar did not just bring along funds and wealth, but also transatlantic slavery trade. As shown in Figure 9, despite its initial higher land productivity, the buildup of African slaves led to West Indies' long-term relative economic decline. Besides Caribbean "sugar and slavery" (Sheridan 2000[1974]), Spanish-American mines and *mita*, another forced labor system that resembled *repartimiento*, presented a similar case of resource curse. For example, the Potosí silver mines discovery in AD1545, together with the state-owned Huancavelica mines that deposited mercury necessary for silver refinement, motivated *mita* assignment. Between AD1573 and AD1812, *mita* required Peru and Bolivia villages to provide labor quotas for the mining work in Potosí and Huancavelica. Dell (2010) found that *mita* had long-run effects

[56] See Nunn (2014) for a survey of empirical studies concerning the impacts of historical events on current economic development.

of lowering household consumption and increasing children stunting in Peru and Bolivia.

On the other hand, in section 5.1, the United States land acquisition illustrates resource blessing. It happened that the United States enlarged its boarder over areas where native Indian population was thin and at a time when transatlantic slavery trade was abolished. This allowed the United States to enjoy the production scale effect on technological progress without worsening its overall population conduciveness to growth, enabling it to surpass not just its American siblings, but also its motherland Britain eventually. Note the distinction/complementarity between our theory with Acemoglu et al. (2002). Acemoglu et al. (2002) stated that, Europeans were more likely to introduce extractive institutions in (American) colonies with larger initial population, bringing about their relative declines. In ours, the emphasis is on population structure: it was the high proportion of population being affected by the forced labor system, that cursed the colonies with reversal of fortune. If the extractive institutions affected only a small portion of the population (for example, the Indian Removal Act of 1830 in the United States), its effect on economic growth could be minimal.

8.5 Eurasian UGT versus American UGT

Our theory addresses one issue that traditional unified growth theories fail to convey: the absolute decline of per capita income in American countries during the colonization era. Traditional unified growth theories (Galor and Weil 2000; Galor and Moav 2002) predict that over the course of economic development, an economy experiences first Malthusian income stagnation, and then Post-Malthusian and Modern Growth when per capita income keeps on rising. However, we witness absolute per capita income declines in the Thirteen Colonies during AD1700-AD1774 (Table 2), in Spanish-Mexico and in Caribbean countries during AD1700-AD1820 (Table 8). Our model reconciles these absolute decline patterns (panel (a) in Figures 4, 9 and 10). The underlying mechanism is that transatlantic migration and slavery trade added demographic pressure into the starting-thin American population. In the eighteenth century when technological progress was slow, such demographic pressure exerted a significant and dominant population dilution effect on per capita income, leading to the absolute per capita income declines. Yet, for the sake of simplicity, we have treated variables like fertility, food prices as outside and constant factors in our model. It would be interesting to consider how these variables are codetermined in unified growth models.[57]

More generally, we need two sets of unified growth theories to explain the world economic history, one for the Eastern Hemisphere (*Eurasian UGT*) and another for the Western Hemisphere (*American UGT*).[58] In the Eastern Hemisphere, during the long Malthusian era, domestic

[57] For example, Malthus (1826, 517) stated that the fast population growth in the United States at the time of his writing was the result of a combination of factors:

> "*[O]n account of the extreme cheapness of good land, and a situation favourable to the exportation of grain, a capital could not be more advantageously employed than in agriculture; which, at the same time that it affords the greatest quantity of healthy work, supplies the most valuable produce to the society. The consequence of these favourable circumstances united, was a rapidity of increase almost without parallel in history.*"

[58] Ho (2016a, 2016b) posited Eurasian UGTs. In comparison, this paper develops an American UGT.

population stockpiled and technology advanced due to the population scale effect on technological progress. At some point in time technology growth was fast enough so that economies broke away from the Malthusian Trap of income stagnation, and entered the Post-Malthusian or Modern Growth era (Galor and Weil 2000). This characterizes the historical experience of Eurasian countries, such as Britain and China. However, in the Western Hemisphere, it was not the native Indians who built up large enough population stocks for ideas to spread and pulled the economies out of the Malthusian Trap. They had been destroyed even before they had a chance to do so. Since the arrival of Christopher Columbus in AD1492, the Europeans brought along with them "guns, germs and steel" to conquer the New World at a dramatic rate. At the time of the collapse of the Inca Empire in AD1533, the population density in America was about thirty-times thinner than that in Europe (Maddison 2003, 113), while the American technology level (in terms of wide adoption of iron tools) lagged the European counterpart by more than two millennia (Diamond 1997, Table 18.1). According to the European experience, both the population density and technology level in America were far from reaching the Post-Malthusian cutting edges.

It was at this time that the Columbian Exchange of human population took place in the American landscapes, where the native American Indians were rapidly replaced by European Whites and African Blacks from the other side of the Atlantic Ocean, generating structural breaks on the original Malthusian population-technology evolution dynamics, and furnishing the New World with a new start.[59] Therefore AD1492 would be a natural starting point for us to construct unified growth theories for the Western Hemisphere, when transatlantic labor movement and slavery institution soon followed.[60] Due to data availability, our model simulations start with AD1700 but we believe our unified growth theory applies to America since Christopher Columbus and his crews spotted the New Land and set foot on the New World.[61] By the late-nineteenth century, the Whites and the Blacks had built up large enough population and technology stocks in America, and the slavery institutions had been abolished. Then the unified growth theories in the two Hemispheres converged to explain the development in individual nations and divergence in the world economy in the centuries to come.

9 CONCLUSION

[59] Since Christopher Columbus's arrival, in the next three centuries American countries in general experienced first Indian depopulations and then fast rates of Whites and Blacks reproduction. From Maddison (2008), the population in the future United States was two million in AD1500, and it dropped to one million in AD1700, and then it rebounded to about ten million in AD1820. For Latin America, the figures were about eighteen million in AD1500, about nine million in AD1600 and about twenty-two million in AD1820. Diamond (1997, 354) labeled the capture of Atahuallpa, the last independent ruler in Inca Empire, as a symbol of the "collision of hemispheres", when then the largest population replacement in recorded history began in America's land.

[60] Borrowing Blaut (1992, 1)'s words: "the date 1492 represents the breakpoint between two fundamentally different evolutionary epochs."

[61] See Christopher Columbus's quote ahead of the Introduction. Columbus brought the idea of taking advantage of the "brazilwood" and Indian "slaves" in West Indies during his third voyage in AD1498.

This paper develops a unified growth theory that argues for the importance of population in blending geography and institution, to account for development and divergence in American landscapes during the colonization era. America witnessed continuous transatlantic migration and slavery import during the early Modern Period. By the turn of the nineteenth century, American landscapes had been dominated by the descendants of European Whites and African Blacks. To reconcile the American development process and the reversal of fortune, we construct a unified growth model with transatlantic migration and slavery trade, where the pace of technological progress depends on the White-Black population structure. Slavery institution deprives Black slaves' labor and wealth, removing their incentives to learn and make improvements. Therefore, an American region/country with a greater Black population share would be less conducive to economic progress during the colonization era.

In sections 4-6, we apply the model to the Thirteen Colonies/United States. Our simulation reconciles the fall and rise of per capita income in the Thirteen Colonies/United States during AD1700-AD1860. We found that territorial acquisition is quantitatively important in explaining the rises in British migrants and United States' per capita income growth rate during the early-nineteenth century. For slavery trade abolition, besides its direct impact on banning slavery imports, the policy had little quantitative consequences on demographic-economic development in the United States. Then our model reconciles the reversal of fortune between US-North and US-South in AD1800-AD1840 (Lindert and Williamson 2016). From the calibration, the root causes of the relative fall of the US-South economy were its poorer demographic performance, lower Whites' willingness to immigrate and smaller slavery trade cost parameter.

We put forward the GeoPopulation-Institution hypothesis to account for the above parameter differences. The hypothesis can be split into three parts: (1) the geography channel: disease environment, soil and climate conditions, and land abundance affected the willingness of Europeans to settle and for colonial producers to import Black slaves in an American region/country; (2) the population channel: corresponding to the above willingness, domestic labor scarcity and political environment, transatlantic migration and slavery trade took place and shaped the demographic process; and (3) the institution channel: as a result of slavery institution, the change in White-Black population mix affected economic growth through the population composition effect on technological progress. The GeoPopulation-Institution hypothesis predicts that, an American region/country with poor demographic performance would discourage European migration and promote African slavery import. This would translate into the relative buildup of Black slavery population and curse the American region/country with a reversal of fortune. Our hypothesis explains the relative decline of US-South.

In section 7, we apply the unified growth model and the GeoPopulation-Institution hypothesis to account for the reversal of fortune among three groups of American countries - Spanish-type resource-exploitation countries, Portuguese-type sugar-exporting countries and United-States-type White-populated countries (Engerman and Sokoloff 1997). Spanish-type countries were characterized by initially dense Indian populations and rich mineral resources. Migration restrictions that kept the Europeans away from Spanish colonies were prevalent in keeping defense costs down and protecting the elites' privileges. Colonial producers responded to the labor scarcity problem by heavy exploitation of native Indians and slavery Africans through

forced labor systems. Through an adverse population composition effect on technological progress, this cursed the Spanish-type countries with relative economic decline. For the Portuguese-type countries, the local disease environment and intensive plantation tasks made Europeans averse to migrating to the sugar islands/countries. With few political obstacles, colonial producers turned to importing African slaves, tilting the population there Black. Under the slavery institution, the extremely high Black population share hindered technological progress in the sugar islands/countries, leading to their relative decline.

Contrary to the above two cases, United-States-type countries (the United States and Canada) possessed neither dense populations and rich resources to be exploited, nor favorable soils and climates for sugar plantation at the outset of the colonization era. There was little incentive for the colonial producers (or European powers) to import Black slaves (or introduce forced labor systems) into these countries, and so the populations there were dominated by the descendants of European Whites, who enjoyed economic freedom. The extremely high White population shares provided these countries social capabilities conducive to economic progress, allowing them to eventually gain economic supremacy in the American continents by the early-nineteenth century. Our theory also implies that, after the abolition of slavery institution in America, the population composition effect on technological progress would fade away and a reversal of fortune would become less of a feature in American development. This fits well into the reality that the most prosperous countries (the United States and Canada) by AD1870, the time when most American countries had abolished slavery, have been retaining their per capita income lead in America till today (Maddison 2008).

Our unified growth model provides a quantitative reconciliation of demographic-economic growth paths in the Western Hemisphere during the colonization era, and the GeoPopulation-Institution hypothesis provides a unified explanation for development and divergence in the New World economies. To put our research one step further, the New World story is just one case that illustrates the importance of taking at least geography, population and institution *simultaneously* into account when thinking about economic development and divergence issues. Geography, population and institution are inseparable components in understanding economic growth. We do not live in a null space, a class-free society, or a power vacuum. In response to inquiries on the wealth of nations, it is perhaps fruitful to direct our research focus on how demographic-economic variables interact with socio-political environment in time- and spatial-specific contexts. The better we understand economic history, the better we are able to shape our future.

Appendix 1: Proofs

Proposition 1: $\frac{\partial M_t}{\partial z_t^A} > 0$ and $\frac{\partial Q_t}{\partial z_t^A} > 0$; $\frac{\partial M_t}{\partial z_t^B} < 0$ and $\frac{\partial Q_t}{\partial z_t^B} > 0$

Proof: Use (2), (11), (13) to get $M_t = m[z_t^A \cdot \alpha(L_t^A)^{\alpha-1}(T^A)^{1-\alpha} - z_t^B \cdot \alpha(L_t^B)^{\alpha-1}(T^B)^{1-\alpha}]$, with (4), (5), (7) we obtain

(A.1) $$M_t = m\left\{ z_t^A \cdot \alpha \left[\underbrace{\left(1+g^{L^H}\right)L_{t-1}^H + M_t + \left(1+g^{L^F}\right)L_{t-1}^F + Q_t}_{L_t^A} \right]^{\alpha-1} (T^A)^{1-\alpha} - z_t^B \cdot \right.$$

$$\left. \alpha \left[\underbrace{\left(1+g^{L^B}\right)L_{t-1}^B}_{L_t^B} \right]^{\alpha-1} (T^B)^{1-\alpha} \right\} .$$

Note (13) and (14) implies

(A.2) $$w_t^A = 2fQ_t \ .$$

Taking total derivatives of (A.1) with respect to z_t^A to obtain

(A.3) $$\frac{\partial M_t}{\partial z_t^A} = m\alpha(T^A)^{1-\alpha}\left[(L_t^A)^{\alpha-1} + z_t^A(\alpha-1)(L_t^A)^{\alpha-2}\left(\frac{\partial M_t}{\partial z_t^A} + \frac{\partial Q_t}{\partial z_t^A}\right)\right] .$$

Taking total derivatives of (A.2) with respect to z_t^A, and make use of $\frac{\partial M_t}{\partial z_t^A} = m\frac{\partial w_t^A}{\partial z_t^A}$ (from (2)) to obtain

(A.4) $$\frac{\partial Q_t}{\partial z_t^A} = \left(\frac{1}{2fm}\right)\frac{\partial M_t}{\partial z_t^A} \ .$$

Combine (A.3) and (A.4) to get

(A.5) $$\frac{\partial M_t}{\partial z_t^A} = \frac{m\alpha\left(L_t^A\right)^{\alpha-1}\left(T^A\right)^{1-\alpha}}{1-m\alpha(\alpha-1)z_t^A\left(L_t^A\right)^{\alpha-2}\left(T^A\right)^{1-\alpha}\left(1+\frac{1}{2fm}\right)} > 0 \ .$$

By (A.4) $\frac{\partial Q_t}{\partial z_t^A} > 0$ too.

Taking total derivatives of (A.1) with respect to z_t^B to obtain

(A.6) $$\frac{\partial M_t}{\partial z_t^B} = m\left[\alpha(\alpha-1)z_t^A(L_t^A)^{\alpha-2}(T^A)^{1-\alpha}\left(\frac{\partial M_t}{\partial z_t^B} + \frac{\partial Q_t}{\partial z_t^B}\right) - \alpha(L_t^B)^{\alpha-1}(T^B)^{1-\alpha}\right] .$$

Use (3), (4), (5) to rewrite (13) as $w_t^A = z_t^A \cdot \alpha\left[\left(1+g^{L^H}\right)L_{t-1}^H + M_t + \left(1+g^{L^F}\right)L_{t-1}^F + Q_t\right]^{\alpha-1}(T^A)^{1-\alpha}$. Taking total derivatives of this expression and (A.2) with respect to z_t^B, we get

(A.7) $$\frac{\partial Q_t}{\partial z_t^B} = \frac{1}{2f}\left[\alpha(\alpha-1)z_t^A(L_t^A)^{\alpha-2}(T^A)^{1-\alpha}\left(\frac{\partial M_t}{\partial z_t^B} + \frac{\partial Q_t}{\partial z_t^B}\right)\right]$$ or

$$\frac{\partial Q_t}{\partial z_t^B} = \frac{\frac{1}{2f}\alpha(\alpha-1)z_t^A\left(L_t^A\right)^{\alpha-2}\left(T^A\right)^{1-\alpha}}{1-\frac{1}{2f}\alpha(\alpha-1)z_t^A\left(L_t^A\right)^{\alpha-2}\left(T^A\right)^{1-\alpha}} \cdot \frac{\partial M_t}{\partial z_t^B} \ .$$

Plug (A.7) into (A.6), rearranging to get

(A.8) $$\frac{\partial M_t}{\partial z_t^B} = \frac{-m\alpha\left(L_t^B\right)^{\alpha-1}\left(T^B\right)^{1-\alpha}}{1-m\alpha(\alpha-1)z_t^A\left(L_t^A\right)^{\alpha-2}\left(T^A\right)^{1-\alpha}\left[\frac{1}{1-\frac{1}{2f}\alpha(\alpha-1)z_t^A\left(L_t^A\right)^{\alpha-2}\left(T^A\right)^{1-\alpha}}\right]} < 0 \ .$$

By (A.7) $\frac{\partial Q_t}{\partial z_t^B} > 0$.

Proposition 2: $\frac{\partial M_t}{\partial\left(1+g^{L^H}\right)L_{t-1}^H} < 0$ and $\frac{\partial Q_t}{\partial\left(1+g^{L^H}\right)L_{t-1}^H} < 0$; $\frac{\partial M_t}{\partial\left(1+g^{L^F}\right)L_{t-1}^F} < 0$ and $\frac{\partial Q_t}{\partial\left(1+g^{L^F}\right)L_{t-1}^F} <$

0; $\frac{\partial M_t}{\partial\left(1+g^{L^B}\right)L_{t-1}^B} > 0$ and $\frac{\partial Q_t}{\partial\left(1+g^{L^B}\right)L_{t-1}^B} < 0$

Proof: Taking total derivatives of (A.1) with respect to $\left(1+g^{L^H}\right)L_{t-1}^H$, which reflects the White population originating from natural increase at time t, to obtain

(A.9) $$\frac{\partial M_t}{\partial\left(1+g^{L^H}\right)L_{t-1}^H} = mz_t^A\alpha(\alpha-1)(L_t^A)^{\alpha-2}(T^A)^{1-\alpha}\left[1+\frac{\partial M_t}{\partial\left(1+g^{L^H}\right)L_{t-1}^H}+\frac{\partial Q_t}{\partial\left(1+g^{L^H}\right)L_{t-1}^H}\right] .$$

Taking total derivatives of (A.2) with respect to $\left(1+g^{L^H}\right)L_{t-1}^H$ to obtain $\frac{\partial Q_t}{\partial\left(1+g^{L^H}\right)L_{t-1}^H} = \left(\frac{1}{2f}\right)\frac{\partial w_t^A}{\partial\left(1+g^{L^H}\right)L_{t-1}^H}$. Note from (2) that $\frac{\partial M_t}{\partial\left(1+g^{L^H}\right)L_{t-1}^H} = m\frac{\partial w_t^A}{\partial\left(1+g^{L^H}\right)L_{t-1}^H}$, which implies

(A.10) $$\frac{\partial Q_t}{\partial\left(1+g^{L^H}\right)L_{t-1}^H} = \left(\frac{1}{2fm}\right)\frac{\partial M_t}{\partial\left(1+g^{L^H}\right)L_{t-1}^H} .$$

Combine (A.9) and (A.10) to get

(A.11) $$\frac{\partial M_t}{\partial\left(1+g^{L^H}\right)L_{t-1}^H} = \frac{m\alpha(\alpha-1)z_t^A\left(L_t^A\right)^{\alpha-2}\left(T^A\right)^{1-\alpha}}{1-m\alpha(\alpha-1)z_t^A\left(L_t^A\right)^{\alpha-2}\left(T^A\right)^{1-\alpha}\left(1+\frac{1}{2fm}\right)} < 0 .$$

By (A.10) $\frac{\partial Q_t}{\partial\left(1+g^{L^H}\right)L_{t-1}^H} < 0$ too.

Taking total derivatives of (A.1) with respect to $\left(1+g^{L^F}\right)L_{t-1}^F$, which reflects the Black population originating from natural increase at time t, to obtain

(A.12) $$\frac{\partial M_t}{\partial\left(1+g^{L^F}\right)L_{t-1}^F} = mz_t^A\alpha(\alpha-1)(L_t^A)^{\alpha-2}(T^A)^{1-\alpha}\left[1+\frac{\partial M_t}{\partial\left(1+g^{L^F}\right)L_{t-1}^F}+\frac{\partial Q_t}{\partial\left(1+g^{L^F}\right)L_{t-1}^F}\right] .$$

Taking total derivatives of (A.2) with respect to $\left(1+g^{L^F}\right)L_{t-1}^F$ to obtain $\frac{\partial Q_t}{\partial\left(1+g^{L^F}\right)L_{t-1}^F} = \left(\frac{1}{2f}\right)\frac{\partial w_t^A}{\partial\left(1+g^{L^F}\right)L_{t-1}^F}$. Note from (2) that $\frac{\partial M_t}{\partial\left(1+g^{L^F}\right)L_{t-1}^F} = m\frac{\partial w_t^A}{\partial\left(1+g^{L^F}\right)L_{t-1}^F}$, which implies

(A.13) $$\frac{\partial Q_t}{\partial\left(1+g^{L^F}\right)L_{t-1}^F} = \left(\frac{1}{2fm}\right)\frac{\partial M_t}{\partial\left(1+g^{L^F}\right)L_{t-1}^F} .$$

Combine (A.12) and (A.13) to get

(A.14) $$\frac{\partial M_t}{\partial\left(1+g^{L^F}\right)L_{t-1}^F} = \frac{m\alpha(\alpha-1)z_t^A\left(L_t^A\right)^{\alpha-2}\left(T^A\right)^{1-\alpha}}{1-m\alpha(\alpha-1)z_t^A\left(L_t^A\right)^{\alpha-2}\left(T^A\right)^{1-\alpha}\left(1+\frac{1}{2fm}\right)} < 0 .$$

By (A.13) $\frac{\partial Q_t}{\partial\left(1+g^{L^F}\right)L_{t-1}^F} < 0$ too.

Taking total derivatives of (A.1) with respect to $\left(1+g^{L^B}\right)L_{t-1}^B$, which reflects country B's population originating from natural increase at time t, yields

(A.15) $$\frac{\partial M_t}{\partial\left(1+g^{L^B}\right)L_{t-1}^B} = -m\alpha(\alpha-1)z_t^B(L_t^B)^{\alpha-2}(T^B)^{1-\alpha} > 0 .$$

Taking total derivatives of (A.2) with respect to $\left(1+g^{L^B}\right)L_{t-1}^B$ to get

(A.16) $$\frac{\partial Q_t}{\partial\left(1+g^{L^B}\right)L_{t-1}^B}=\left(\frac{1}{2f}\right)\frac{\partial w_t^A}{\partial\left(1+g^{L^B}\right)L_{t-1}^B}\ .$$

Use (3), (4), (5) to rewrite (13) as $w_t^A=z_t^A\cdot\alpha\left[\left(1+g^{L^H}\right)L_{t-1}^H+M_t+\left(1+g^{L^F}\right)L_{t-1}^F+Q_t\right]^{\alpha-1}(T^A)^{1-\alpha}$. Taking total derivatives with respect to $\left(1+g^{L^B}\right)L_{t-1}^B$ and plug it into (A.16) to obtain

(A.17) $$\frac{\partial Q_t}{\partial\left(1+g^{L^B}\right)L_{t-1}^B}=\frac{\frac{1}{2f}\alpha(\alpha-1)z_t^A\left(L_t^A\right)^{\alpha-2}\left(T^A\right)^{1-\alpha}\frac{\partial M_t}{\partial\left(1+g^{L^B}\right)L_{t-1}^B}}{1-\frac{1}{2f}\alpha(\alpha-1)z_t^A\left(L_t^A\right)^{\alpha-2}\left(T^A\right)^{1-\alpha}}<0,$$ where we have use (A.15).

Proposition 3: $\frac{\partial M_t}{\partial T^A}>0$ and $\frac{\partial Q_t}{\partial T^A}>0$

Proof: Taking total derivatives of (A.1) with respect to T^A to get

(A.18) $$\frac{\partial M_t}{\partial T^A}=m\left[z_t^A\alpha(1-\alpha)(L_t^A)^{\alpha-1}(T^A)^{-\alpha}+z_t^A\alpha(\alpha-1)(L_t^A)^{\alpha-2}(T^A)^{1-\alpha}\left(\frac{\partial M_t}{\partial T^A}+\frac{\partial Q_t}{\partial T^A}\right)\right]\ .$$

Taking total derivatives of (A.2) with respect to T^A, together with $\frac{\partial M_t}{\partial T^A}=m\frac{\partial w_t^A}{\partial T^A}$ (from (2)) to get

(A.19) $$\frac{\partial Q_t}{\partial T^A}=\left(\frac{1}{2fm}\right)\frac{\partial Q_t}{\partial T^A}\ .$$

Combine (A.18) and (A.19) to obtain

(A.20) $$\frac{\partial M_t}{\partial T^A}=\frac{mz_t^A\alpha(1-\alpha)\left(L_t^A\right)^{\alpha-1}\left(T^A\right)^{-\alpha}}{1-mz_t^A\alpha(\alpha-1)\left(L_t^A\right)^{\alpha-2}\left(T^A\right)^{1-\alpha}\left(1+\frac{1}{2fm}\right)}>0\ .$$

By (A.19) $\frac{\partial Q_t}{\partial T^A}>0$ too.

Proposition 4: $\frac{\partial M_t}{\partial f}>0$ and $\frac{\partial Q_t}{\partial f}<0$

Proof: Taking total derivatives of (A.1) with respect to f to obtain

(A.21) $$\frac{\partial M_t}{\partial f}=mz_t^A\alpha(\alpha-1)(L_t^A)^{\alpha-1}(T^A)^{1-\alpha}\left(\frac{\partial M_t}{\partial f}+\frac{\partial Q_t}{\partial f}\right)\ .$$

Taking total derivatives of (A.2) with respect to f to get $\frac{\partial w_t^A}{\partial f}=2f\frac{\partial Q_t}{\partial f}+2Q_t$. Note from (2) that $\frac{\partial M_t}{\partial f}=m\frac{\partial w_t^A}{\partial f}$, which implies

(A.22) $$\frac{\partial Q_t}{\partial f}=-\frac{1}{f}Q_t+\left(\frac{1}{2fm}\right)\frac{\partial M_t}{\partial f}\ .$$

Combine (A.21) and (A.22) to get

(A.23) $$\frac{\partial M_t}{\partial f}=\frac{-m\alpha(\alpha-1)z_t^A\left(L_t^A\right)^{\alpha-2}\left(T^A\right)^{1-\alpha}\left(\frac{1}{f}Q_t\right)}{1-m\alpha(\alpha-1)z_t^A\left(L_t^A\right)^{\alpha-2}\left(T^A\right)^{1-\alpha}\left(1+\frac{1}{2fm}\right)}>0\ .$$

Plug (A.23) into (A.22) to get

(A.24) $$\frac{\partial Q_t}{\partial f} = -\frac{1}{f} Q_t \left[\frac{1 - m\alpha(\alpha-1) z_t^A (L_t^A)^{\alpha-2} (T^A)^{1-\alpha}}{1 - m\alpha(\alpha-1) z_t^A (L_t^A)^{\alpha-2} (T^A)^{1-\alpha} \left(1 + \frac{1}{2fm}\right)} \right] < 0 \ .$$

Proposition 5: $\frac{\partial M_t}{\partial m} > 0$ and $\frac{\partial Q_t}{\partial m} < 0$, given $w_t^A > w_t^B$

Proof: Taking total derivatives of (A.1) with respect to m to obtain

(A.25) $$\frac{\partial M_t}{\partial m} = (w_t^A - w_t^B) + m z_t^A \alpha(\alpha - 1)(L_t^A)^{\alpha-2}(T^A)^{1-\alpha} \left(\frac{\partial M_t}{\partial m} + \frac{\partial Q_t}{\partial m} \right) \ .$$

Taking total derivatives of (A.2) with respect to m to get $\frac{\partial Q_t}{\partial m} = \left(\frac{1}{2f}\right) \frac{\partial w_t^A}{\partial m}$. Note from (2) that $\frac{\partial M_t}{\partial m} = (w_t^A - w_t^B) + m \frac{\partial w_t^A}{\partial m}$. Combine the two expressions to eliminate $\frac{\partial w_t^A}{\partial m}$ and get

(A.26) $$\frac{\partial Q_t}{\partial m} = -\frac{1}{2fm}(w_t^A - w_t^B) + \left(\frac{1}{2fm}\right) \frac{\partial M_t}{\partial m} \ .$$

Combine (A.25) and (A.26) to get

(A.27) $$\frac{\partial M_t}{\partial m} = \frac{(w_t^A - w_t^B)\left[1 - \alpha(\alpha-1) z_t^A (L_t^A)^{\alpha-2} (T^A)^{1-\alpha} \left(\frac{1}{2f}\right)\right]}{1 - m\alpha(\alpha-1) z_t^A (L_t^A)^{\alpha-2} (T^A)^{1-\alpha} \left(1 + \frac{1}{2fm}\right)} \begin{array}{l} > 0 \ if \ w_t^A > w_t^B \\ < 0 \ otherwise \end{array} \ .$$

Plug (A.27) into (A.26) to get

(A.28) $$\frac{\partial Q_t}{\partial m} = \frac{1}{2fm}(w_t^A - w_t^B) \left[\frac{m\alpha(\alpha-1) z_t^A (L_t^A)^{\alpha-2} (T^A)^{1-\alpha}}{1 - m\alpha(\alpha-1) z_t^A (L_t^A)^{\alpha-2} (T^A)^{1-\alpha} \left(1 + \frac{1}{2fm}\right)} \right] \begin{array}{l} < 0 \ if \ w_t^A > w_t^B \\ > 0 \ otherwise \end{array} \ .$$

Appendix 2: Adjustment mechanisms

Figure A.1 illustrates the mechanism behind proposition 1*(i)*. It depicts the labor market equilibrium across two consecutive time periods ($t = 1$ and $t = 2$) when technological progress occurs in country A. For simplicity, suppose there is neither technological progress in country B nor natural population growth ($g^{L^H} = g^{L^F} = g^{L^B} = 0$). In the left panel, the upward sloping line represents the Harris-Todaro migration curve (2), while the downward sloping line $MPL_1^H(L_1^F)$ depicts the marginal product of Whites at time 1 (right hand side of (13)). In the right panel, the upward sloping line shows the marginal slavery trade cost curve, while the downward sloping line $MPL_1^F(L_1^H)$ depicts the marginal product of Blacks at time 1 (equation (14)).[62] The original equilibrium is at E_1.

INSERT FIGURE A.1 HERE

As the economy progresses from time 1 to time 2, technological progress in country A moves up the marginal product curves for the Whites and for the Blacks to $MPL_2^H(L_1^F)$ and $MPL_2^F(L_1^H)$ respectively. In the left panel, the new marginal product curve intersects the H-T

[62] We state the equations for the four curves in Figure A.1 as follows:
H-T migration curve: $w_t^A = \frac{1}{m}\left[L_t^H - \left(1 + g^{L^H}\right) L_{t-1}^H + m w_t^B\right]$
MPL_t^H: $w_t^A = z_t^A \cdot \alpha(L_t^H + L_t^F)^{\alpha-1}(T^A)^{1-\alpha}$
Marginal slavery trade cost curve: marginal cost $= 2f\left[L_t^F - \left(1 + g^{L^F}\right) L_{t-1}^F\right]$
MPL_t^F: marginal product of the Blacks $= z_t^A \cdot \alpha(L_t^H + L_t^F)^{\alpha-1}(T^A)^{1-\alpha}$

migration curve at point E' where $L^H = L^{H\prime}$. The higher colony wage draws migrants into country A, raising total population in country A, and depressing the marginal product curve for the Blacks in the right panel to $MPL_2^F(L^{H\prime})$. However, in general E' is still not the new equilibrium. Without new slavery imports, the marginal product of Blacks is higher than the marginal cost of importing slaves at $L^F = L_1^F$ in the right panel. The colonial producer will import slaves until the new marginal product curve for the Blacks $MPL_2^F(L_2^H)$ intersects the marginal slavery trade cost curve at $L^F = L_2^F$ in the right panel, where L_2^H corresponds to the equilibrium White population such that the H-T migration curve intersects the new marginal product curve for the Whites $MPL_2^H(L_2^F)$ in the left panel. Point E_2 is the new equilibrium, with European migrants inflow $M_2 = L_2^H - L_1^H$ and African slaves import $Q_2 = L_2^F - L_1^F$.

To generalize the results of the above exercise, technological progress and natural population growth affect transatlantic migration and slavery trade through interactions between diminishing marginal productivities of Whites and Blacks, potential migrants' response to home-colony wage differential and colonial producer's rent maximizing behavior.[63]

Appendix 3: Calibration for simulating reversal of fortune between US-North and US-South

Similar to section 4.3, we calibrate the parameters to match historical land areas, population, income levels and growth, migrations and slavery imports in the three regions/countries. Due to data limitation, in most cases we calibrate parameters using AD1700-AD1770 data, and assume they remained constant up till AD1860. The main calibration results are:

Land area: Using the states areas being identified as US-North and US-South (U.S. Bureau of the Census 2012, Table 18), the initial land areas covered by the two regions in AD1700 are $424{,}397km^2$ and $480{,}157km^2$ respectively.

Initial population and output: Using AD1700 values from Tables 4 and 6, we take the initial White populations in US-North and US-South to be 141,000 and 99,000 respectively, and the initial Black populations in the two regions to be 6,000 and 16,000 respectively. We keep AD1700 British population $L_1^B = 10{,}490{,}000$. From Table 2, we take the initial per capita income in US-North as the AD1700 simple average of those in New England and Middle Colonies ($y_1^{AN} = \frac{1.76+2.6}{2} = 2.18$), and initial per capita income in US-South as the AD1700 simple average of those in Upper South and Lower South ($y_1^{AS} = \frac{5.11+6.77}{2} = 5.94$). Using (9) and (17), the initial technology levels in the two regions are $z_1^{AN} = 1.15$ and $z_1^{AS} = 2.52$ respectively.

Migration and slavery import: Applying (2) to average decennial migration to US-North

[63] We can do similar exercises to study the effects of technology growth in country B (causing initial upward shift in H-T migration curve), White natural population growth in country A (causing initial downward shift in H-T migration curve), Black natural population growth in country A (causing initial downward shift in marginal slavery trade cost curve) and natural population growth in country B (causing initial downward shift in H-T migration curve) on equilibrium transatlantic migration and slavery trade.

and US-South during AD1700-AD1770 (Table 5) and the implied AD1700 wages, we get $m^N = 369{,}048$ and $m^S = 18{,}870$. Similarly, applying (13)-(14) to average decennial Blacks imported to US-North and US-South during AD1700-AD1770 (Table 7) and the implied AD1700 wages, we obtain $f^N = 0.000436$ and $f^S = 0.0000402$.

Population and income growth: Assuming constant natural population growth rates in the three regions/countries, applying population accumulation equations to AD1700-AD1770 data in Tables 4-7, we obtain $g^{L^{HN}} = 0.29$ and $g^{L^{FN}} = 0.24$ in US-North, $g^{L^{HS}} = 0.15$ and $g^{L^{FS}} = 0.21$ in US-South. We keep $g^{L^B} = 0.086$ in Britain. We calibrate the learning-by-doing parameters and technology diffusion parameters as $\mu_1 = 1.4 \times 10^{-8}$, $\mu_2 = 1.2 \times 10^{-15}$ and $d = 0.02$ to match per capita income growth trends in Britain and in the United States during AD1700-AD1840.

Land acquisition and slavery trade abolition: Similar to sections 5.1 and 5.2, for United States land acquisition, we assume the land areas of both US-North and US-South to be raised by factors of $\frac{864{,}746}{349{,}250}$, $\frac{1{,}681{,}828}{864{,}746}$ and $\frac{2{,}940{,}042}{1{,}681{,}828}$ in AD1790, AD1810 and AD1850 respectively. For slavery trade abolition, we raise f^N and f^S to prohibitively-high levels $f^N = f^S = 1$ from AD1810 onwards.

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TABLE 1

Population composition in selected American regions/countries

	Economy	*Year*	*White (%)*	*Black (%)*	*Indian (%)*
1.	Barbados	1690	25	75	-
2.	Barbados	1801	19.3	80.7	-
3.	Mexico	1793	18	10	72
4.	Peru	1795	12.6	7.3	80.1
5.	Venezuela	1800-09	25	62	13
6.	Cuba	1792	49	51	-
7.	Brazil	1798	31.1	61.2	7.8
8.	Chile	1790	8.3	6.7	85
9.	U.S.-Nation	1860	84.9	14	1.1
10.	U.S. South	1860	61.7	37.7	0.7
11.	U.S. North	1860	96.2	2.6	1.3
12.	Canada	1881	97	0.5	2.5
13.	Argentina	1918	95.6	1.2	3.2

Source: Engerman and Sokoloff (1997) Table 10.4.

TABLE 2

Real per capita income of the Thirteen Colonies, AD1650-AD1774

		1650	**1675**	**1700**	**1725**	**1750**	**1770**	**1774**
US-North	New England	1.13	1.45	1.76	1.88	1.84	2.11	1.93
	Middle Colonies			2.6	2.52	2.6	2.6	2.72
US-South	Upper South		5.98	5.11	4.22	3.94	3.9	3.8
	Lower South			6.77	6.42	5.87	5.11	5.54
All 13 colonies				**3.45**	**3.21**	**3.21**	**3.27**	**3.29**
Britain		1.22	1.52	2.06	2.03	2.09	2.12	1.96

Source: Lindert and Williamson (2016) Table 6, per capita income in bare-bones welfare ratios. Note that in Lindert and Williamson (2016)'s original article, New England includes NH, MA, RI and CT; Middle Colonies includes NY, NJ and PA; Upper South includes VA, MD and DE; Lower South includes GA, NC and SC.

TABLE 3

Per annum real per capita income growth rate of the Thirteen States, AD1774-AD1840

		1774-1800 (%)	1800-1840 (%)
US-North	New England	-0.33	2.44
	Middle Colonies	-0.27	1.77
US-South		-1.35	0.69
All three U.S. regions		-0.86	1.56

Source: Lindert and Williamson (2013) Table 6. Note that in Lindert and Williamson (2013)'s original article, New England includes CT, MA, ME, NH, RI and VT; Middle Colonies (Middle Atlantic) includes NY, NJ, PA, DE, MD and DC; US-South (South Atlantic) includes VA, GA, NC and SC.

TABLE 4

White population of British America, in thousands, by region, AD1620-AD1770

Year	US-North	US-South	West Indies
1620		1 (NA)	
1630	2 (NA)	2 (NA)	2 (NA)
1640	16 (NA)	8 (NA)	14 (NA)
1650	27 (96%)	12 (100%)	44 (75%)
1660	38 (95%)	25 (96%)	47 (58%)
1670	59 (98%)	43 (93%)	44 (46%)
1680	81 (96%)	62 (94%)	42 (36%)
1690	118 (97%)	78 (90%)	37 (27%)
1700	141 (96%)	99 (86%)	33 (22%)
1710	176 (95%)	120 (81%)	30 (17%)
1720	259 (95%)	153 (77%)	35 (17%)
1730	346 (95%)	205 (72%)	37 (14%)
1740	485 (95%)	271 (67%)	34 (12%)
1750	625 (95%)	309 (59%)	35 (11%)
1760	836 (95%)	432 (60%)	41 (10%)
1770	1087 (96%)	587 (59%)	45 (9%)

Source: Galenson (1996) Table 4.2. Parentheses indicating percentage of Whites in population. US-North refers to New England and Middle Colonies, while US-South refers to Upper South and Lower South. New England contains Maine (ME), New Hampshire (NH), Vermont (VT), Plymouth, Massachusetts (MA), Rhode Island (RI) and Connecticut (CT). Middle Colonies contains New York (NY), New Jersey (NJ), Pennsylvania (PA), and Delaware (DE). Upper South contains Maryland (MD) and Virginia (VA). Lower South contains Georgia (GA), North Carolina (NC), and South Carolina (SC). West Indies contains Barbados, Jamaica, Antigua, Montserrat, Nevis, and St. Kitts.

TALBE 5

Decennial net migration of Whites from British Isles to British America, in thousands, by region, AD1630-AD1770

Decade Beginning	US-North	US-South	West Indies
1630	11	11	41
1640	5	14	40
1650	3	18	33
1660	8	20	12
1670	5	18	15
1680	12	13	11
1690	-10	3	19
1700	-4	25	10
1710	30	22	18
1720	13	48	16
1730	36	46	6
1740	3	-1	9
1750	31	33	11
1760	15	32	5
1770	-11	26	11
Total	147	328	257

Source: Galenson (1996) Table 4.5. See Table 4 for definitions of US-North, US-South and West Indies.

TABLE 6

Black population of British America, in thousands, by region, AD1650-AD1770

Year	US-North	US-South	West Indies
1650	1 (4%)	0 (0%)	15 (25%)
1660	2 (5%)	1 (4%)	34 (42%)
1670	1 (2%)	3 (7%)	52 (54%)
1680	3 (4%)	4 (6%)	76 (64%)
1690	4 (3%)	9 (10%)	98 (73%)
1700	6 (4%)	16 (14%)	115 (78%)
1710	9 (5%)	29 (19%)	148 (83%)
1720	15 (5%)	46 (23%)	176 (83%)
1730	18 (5%)	79 (28%)	221 (86%)
1740	26 (5%)	134 (33%)	250 (88%)
1750	32 (5%)	211 (41%)	295 (89%)
1760	42 (5%)	285 (40%)	365 (90%)
1770	50 (4%)	406 (41%)	434 (91%)

Source: Galenson (1996) Table 4.3. Parentheses indicating percentage of Blacks in population. See Table 4 for definitions of US-North, US-South and West Indies.

TABLE 7

Decennial net flow of Blacks to British America
in thousands, by region, AD1650-AD1770

Decade Beginning	US-North	US-South	West Indies
1650	0	1	39
1660	0	2	38
1670	0	2	53
1680	0	8	59
1690	0	9	95
1700	1	13	88
1710	4	17	93
1720	2	17	126
1730	2	40	88
1740	0	59	115
1750	1	21	127
1760	-3	40	86
1770	-7	-10	81
Total	0	219	1088

Source: Galenson (1996) Table 4.6. See Table 4 for definitions of US-North, US-South and West Indies.

TABLE 8

Per capita GDP (in AD1990 international dollars)
of the 3 types of American countries, AD1500-AD2000

		1500	*1600*	*1700*	*1820*	*1870*	*1900*	*2000*
Spanish-type resource-exploitation countries	Mexico	550	755	755	566	642	1,435	-
	Other Spanish America (excluding the Caribbean)	410	431	502	663	683	-	5,508
Portuguese-type sugar-exporting countries	Brazil	400	428	459	646	713	678	5,556
	Caribbean countries	400	430	650	636	549	880	5,634
United-States-type White-populated countries	United States	400	400	527	1,231	2,445	4,091	28,129
	Canada	400	400	430	904	1,695	2,911	22,488

Source: Coatsworth (2005) Table 1, Maddison (2008) for Canada data.

TABLE 9

Benchmark parameters, the Thirteen Colonies, AD1700-AD1780

Symbol	Interpretation	Value
Parameters		
T^A	Land area in Thirteen Colonies	904,554
T^B	Land area in Britain	310,813
m	Willingness to migrate	84,532
f	Slavery trade cost parameter	0.0000226
g^{L^H}	White natural population growth rate in Thirteen Colonies	0.23
g^{L^F}	Black natural population growth rate in Thirteen Colonies	0.22
g^{L^B}	Natural population growth rate in Britain	0.086
μ	Learning-by-doing parameter	3.9×10^{-8}
d	Technology diffusion parameter	0.03
α	Production function parameter	0.4
Initial conditions in AD1700		
L_1^H	Initial White population in Thirteen Colonies	240,000
L_1^F	Initial Black population in Thirteen Colonies	22,000
L_1^B	Initial population in Britain	10,490,000
z_1^A	Initial technology level in Thirteen Colonies	1.64
z_1^B	Initial technology level in Britain	17.0

TABLE 10

Total land area of the United States, AD1776-AD1860

Year	*Total land area (square miles)*
1776	349,250
1790	864,746
1800	864,746
1810	1,681,828
1820	1,749,462
1830	1,749,462
1840	1,749,462
1850	2,940,042
1860	2,969,640

Source: U.S. Bureau of the Census (1975), Historical statistics of the United States, colonial times to 1970, Series J 1-2. The AD1776 land area is based on the total land area of the original Thirteen Colonies calculated in section 4.3, converted to square miles.

TABLE 11

Calibrated parameters, the Thirteen Colonies/United States with land acquisition, AD1700-AD1860

Symbol	Interpretation	Value
Parameters		
T^A	Land area in the United States	904,554 for AD1700-AD1789 $904{,}554 \times \frac{864{,}746}{349{,}250}$ for AD1790-AD1809 $904{,}554 \times \frac{1{,}681{,}828}{349{,}250}$ for AD1810-AD1849 $904{,}554 \times \frac{2{,}940{,}042}{349{,}250}$ for AD1850-AD1860
μ_1	Learning-by-doing parameter	1.4×10^{-8}
μ_2	Learning-by-doing parameter	1.2×10^{-15}
d	Technology diffusion parameter	0.009
$T^B,\ m,\ f,\ g^{L^H},\ g^{L^F},\ g^{L^B},\ \alpha$		Same as Table 9
Initial conditions in AD1700		
$L_1^H,\ L_1^F,\ L_1^B,\ z_1^A,\ z_1^B$		Same as Table 9

TABLE 12

Calibrated parameters, the Thirteen Colonies/United States with land acquisition and slavery trade abolition, AD1700-AD1860

Symbol	Interpretation	Value
Parameters		
f	Slavery trade cost parameter	0.0000226 for AD1700-AD1809 1 for AD1810-AD1860
$T^A,\ T^B,\ m,\ g^{L^H},\ g^{L^F},\ g^{L^B},\ \mu_1,\ \mu_2,\ d,\ \alpha$		Same as Table 11
Initial conditions in AD1700		
$L_1^H,\ L_1^F,\ L_1^B,\ z_1^A,\ z_1^B$		Same as Table 11

TABLE 13

Calibrated parameters, reversal of fortune between US-North and US-South, AD1700-AD1860

Symbol	Interpretation	Value	
		US-North (*N*)	**US-South (*S*)**
Parameters			
T^A	Land area in American region	424,397 for AD1700-AD1789 $424{,}397 \times \frac{864{,}746}{349{,}250}$ for AD1790-AD1809 $424{,}397 \times \frac{1{,}681{,}828}{349{,}250}$ for AD1810-AD1849 $424{,}397 \times \frac{2{,}940{,}042}{349{,}250}$ for AD1850-AD1860	480,157 for AD1700-AD1789 $480{,}157 \times \frac{864{,}746}{349{,}250}$ for AD1790-AD1809 $480{,}157 \times \frac{1{,}681{,}828}{349{,}250}$ for AD1810-AD1849 $480{,}157 \times \frac{2{,}940{,}042}{349{,}250}$ for AD1850-AD1860
T^B	Land area in Britain	310,813	310,813
m	Willingness to migrate	369,048	18,870
f	Slavery trade cost parameter	0.000436 for AD1700-AD1809 1 for AD1810-AD1860	0.0000402 for AD1700-AD1809 1 for AD1810-AD1860
g^{L^H}	White natural population growth rate in American region	0.29	0.15
g^{L^F}	Black natural population growth rate in American region	0.24	0.21
g^{L^B}	Natural population growth rate in Britain	0.086	0.086
μ_1	Learning-by-doing parameter	1.4×10^{-8}	1.4×10^{-8}
μ_2	Learning-by-doing parameter	1.2×10^{-15}	1.2×10^{-15}
d	Technology diffusion parameter	0.02	0.02
α	Production function parameter	0.4	0.4
Initial conditions in AD1700			
L_1^H	Initial White population in American region	141,000	99,000
L_1^F	Initial Black population in American region	6,000	16,000
L_1^B	Initial population in Britain	10,490,000	10,490,000
z_1^A	Initial technology level in American region	1.15	2.52
z_1^B	Initial technology level in Britain	17.0	17.0

TABLE 14

Calibrated parameters, the Thirteen Colonies/United States and West Indies, AD1700-AD1860

Symbol	Interpretation	Value	
		Thirteen Colonies/United States	**West Indies**
Parameters			
T^A	Land area in American country	904,554 for AD1700-AD1789 $904{,}554 \times \frac{864{,}746}{349{,}250}$ for AD1790-AD1809 $904{,}554 \times \frac{1{,}681{,}828}{349{,}250}$ for AD1810-AD1849 $904{,}554 \times \frac{2{,}940{,}042}{349{,}250}$ for AD1850-AD1860	11,904
T^B	Land area in Britain	310,813	310,813
m	Willingness to migrate	84,532	35,096
f	Slavery trade cost parameter	0.0000226 for AD1700-AD1809 1 for AD1810-AD1860	0.00000781 for AD1700-AD1809 1 for AD1810-AD1860
g^{L^H}	White natural population growth rate in American country	0.23	-0.20
g^{L^F}	Black natural population growth rate in American country	0.22	-0.20
g^{L^B}	Natural population growth rate in Britain	0.086	0.086
μ_1	Learning-by-doing parameter	1.4×10^{-8}	1.4×10^{-8}
μ_2	Learning-by-doing parameter	1.2×10^{-15}	1.2×10^{-15}
d	Technology diffusion parameter	0.009	0.009
α	Production function parameter	0.4	0.4
Initial conditions in AD1700			
L_1^H	Initial White population in American country	240,000	33,000
L_1^F	Initial Black population in American country	22,000	115,000
L_1^B	Initial population in Britain	10,490,000	10,490,000
z_1^A	Initial technology level in American country	1.64	19.3
z_1^B	Initial technology level in Britain	17.0	17.0

TABLE 15

Parameters, "US-type country" and "Spanish-type country", AD1700-AD1860

Symbol	Interpretation	Value	
		"US-type country"	**"Spanish-type country"**
Parameters			
T^A	Land area in American country	904,554	904,554
m	Willingness to migrate	84,532	43,857
$T^B,\ f,\ g^{L^H},\ g^{L^F},\ g^{L^B},\ \mu_1,\ \mu_2,\ d,\ \alpha$		Same as Table 11	Same as Table 11
Initial conditions in AD1700			
L_1^H	Initial White population in American country	240,000	$(240{,}000 + 22{,}000) \times 0.0526$
L_1^F	Initial Black population in American country	22,000	$(240{,}000 + 22{,}000) \times 0.9474$
z_1^A	Initial technology level in American country	1.64	2.35
$L_1^B,\ z_1^B$		Same as Table 11	Same as Table 11

TABLE A.1

Estimates of life expectancy at age 30 in selected counties,

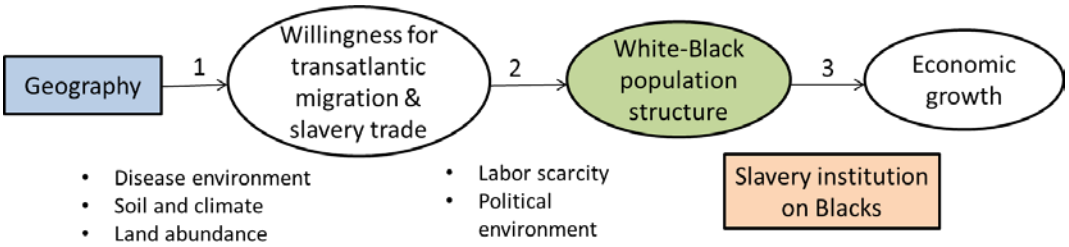
the Thirteen Colonies/United States, the eighteenth century

Place and time	**Life expectancy at 30**
US-North	
Hingham, Mass., 1721-1800	38.4/38.6
Salem, Mass., 18th c.	30.3
Andover, Mass., 1730-1759	36.3
East Haven, Conn., 1773-1822	36.4
Philadelphia gentry, 1700-1800	31.2/33.7
US-South	
Maryland legislators, Native 1700-1767	27
Immigrant 1700-1758	26.6
Middlesex County, Vir., 1650-1710	19.4
Perquimans County, NC., 18th c.	23.1

Source: Wells (1992) Table 3.

FIGURE 1

GeoPopulation-Institution hypothesis

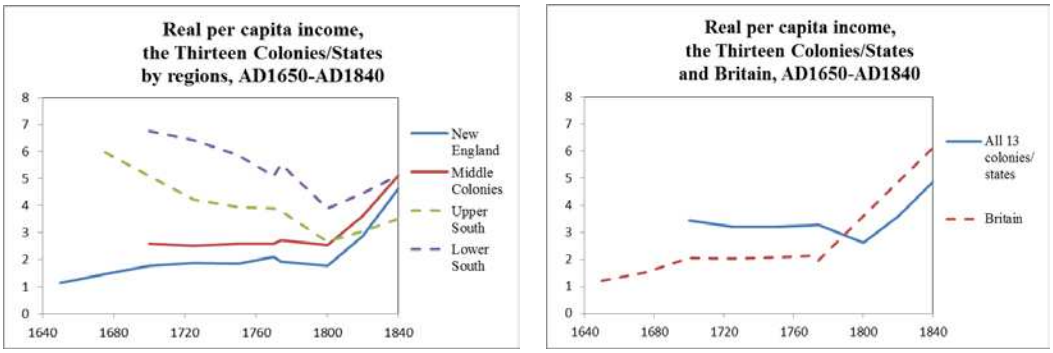


Note: Arrow 1 represents the "geography channel", while arrow 2 represents the "population channel" and arrow 3 represents the "institution channel". See Figure 8 for further breakdown of GeoPopulation-Institution hypothesis.

FIGURE 2

Real per capita income, the Thirteen Colonies/States, AD1650-AD1840

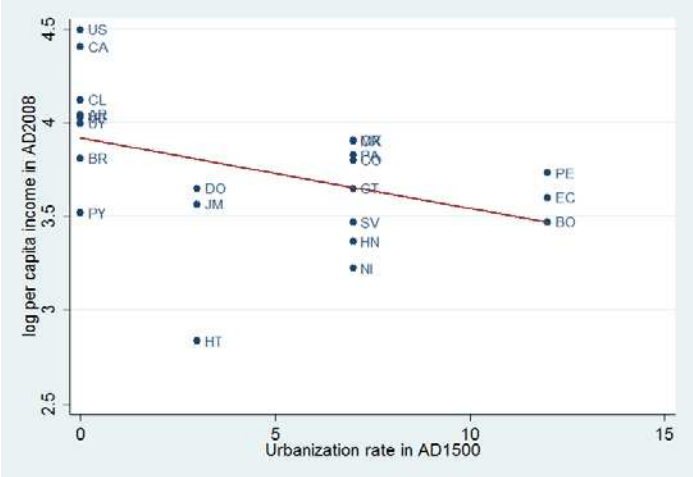
A **B**



Source: Table 2 and Table 3, British per capita income in AD1820 and AD1840 are calculated from comparative per capita income levels between the United Kingdom and the United States in AD1820 and AD1840 respectively (Maddison 2008).

FIGURE 3

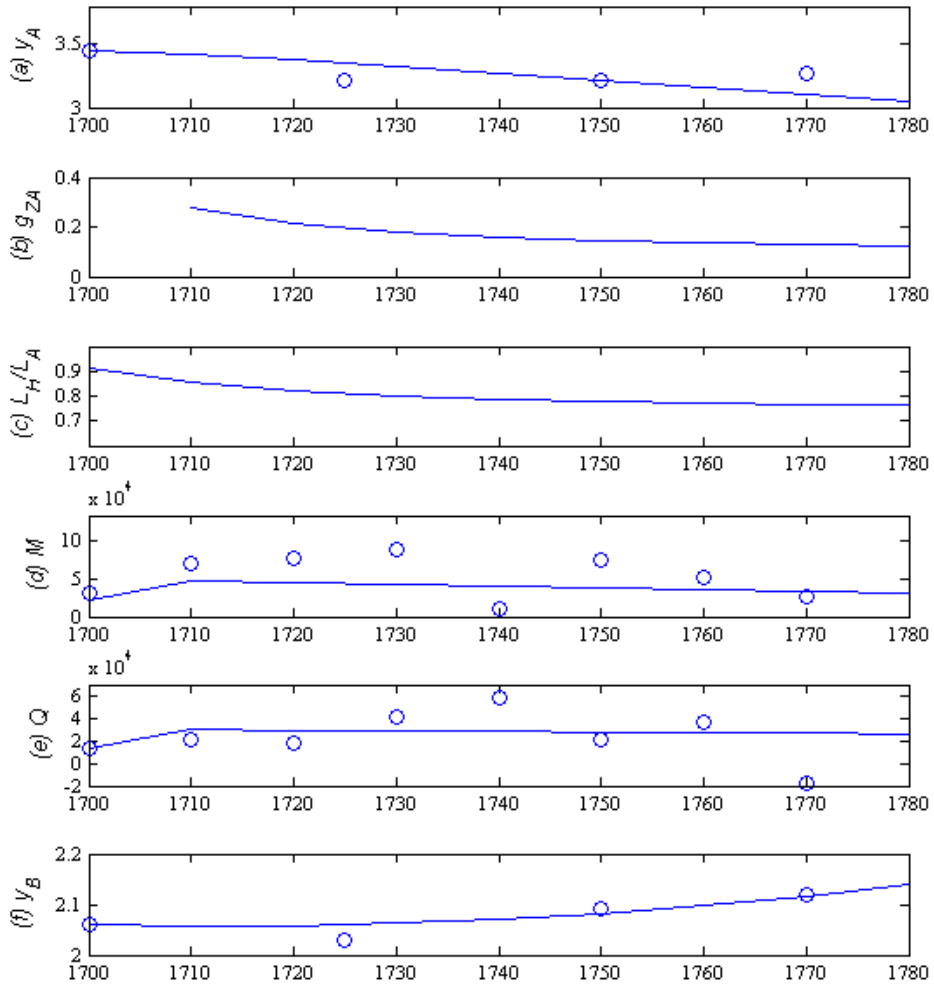
Log per capita income in AD2008 against urbanization rate in AD1500, American countries



Source: Maddison (2008) for per capita income in AD2008, Acemoglu et al. (2002) Appendix 3 for urbanization rate in AD1500.

FIGURE 4

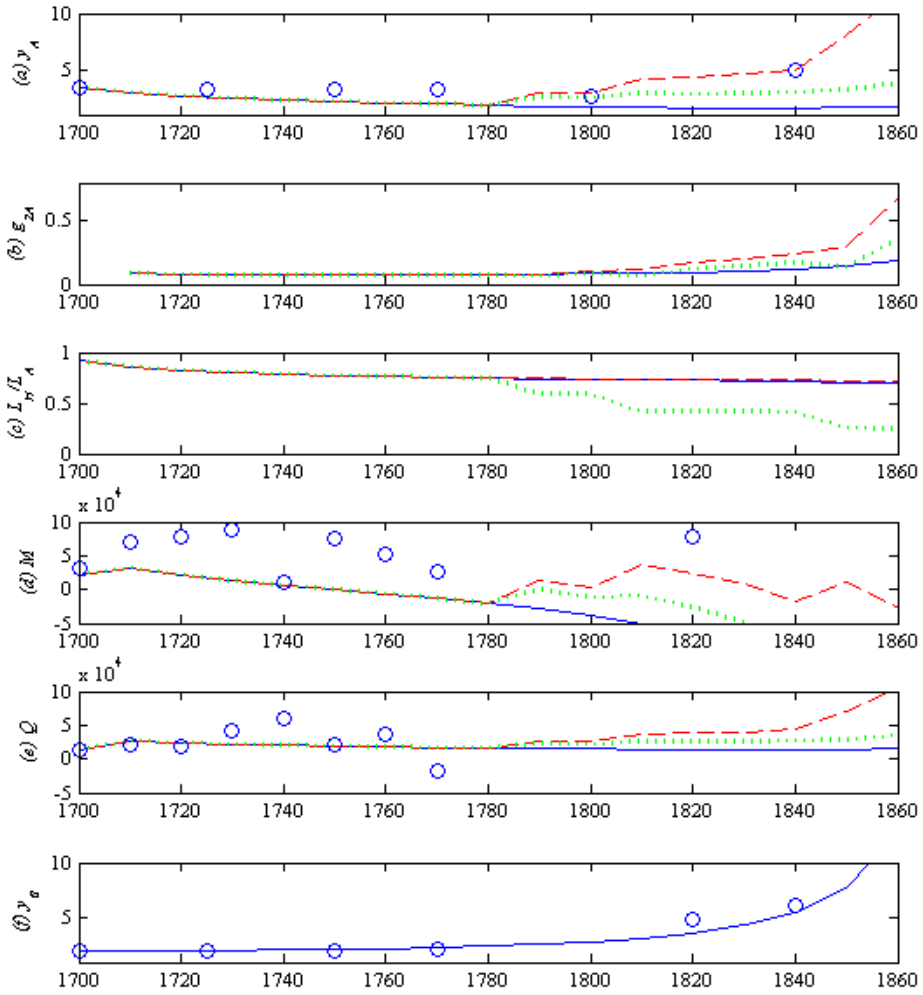
Development paths, the Thirteen Colonies, AD1700-AD1780



Note: Solid (blue) lines: the benchmark economy. The panels show evolution of (a) per capita income in the colony, (b) technology growth rate in the colony, (c) White population share in the colony, (d) number of White migrants to the colony, (e) number of Black slaves imported to the colony, and (f) per capita income in Britain during AD1700-AD1780. (Blue) Dots show the implied data from Tables 2-7.

FIGURE 5

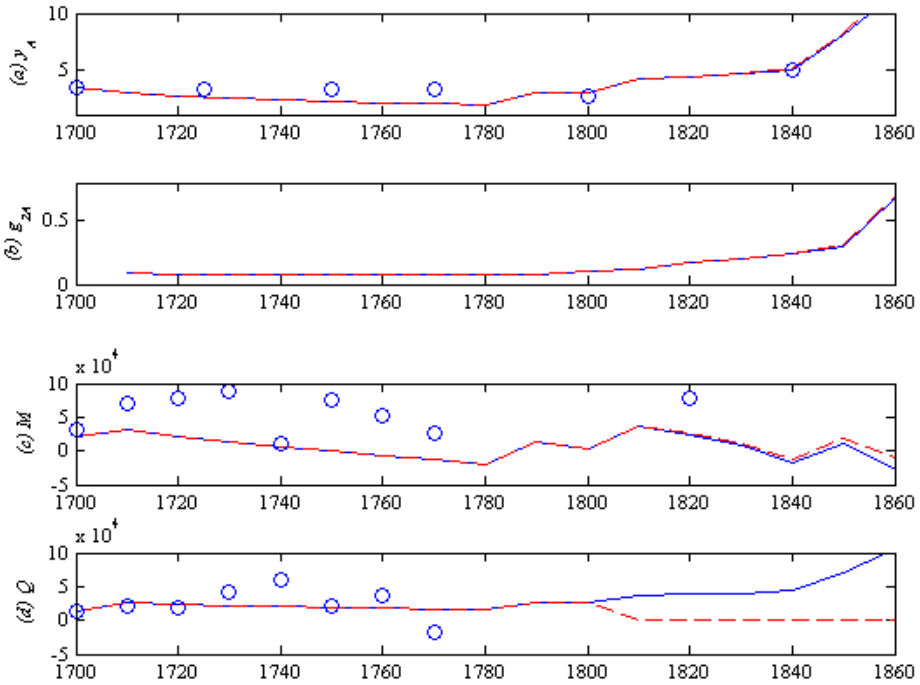
Development paths, the Thirteen Colonies/United States with land acquisition, AD1700-AD1860



Note: Solid (blue) lines: the Thirteen Colonies/United States without land acquisition, parameters from Table 11, except $T^A = 904{,}554$ for all periods. Dashed (red) lines: the Thirteen Colonies/United States with land acquisition, parameters from Table 11. Dotted (green) lines: counterfactual Thirteen Colonies/United States with land expansion into regions with dense Indian population. See Figure 4 for labels.

FIGURE 6

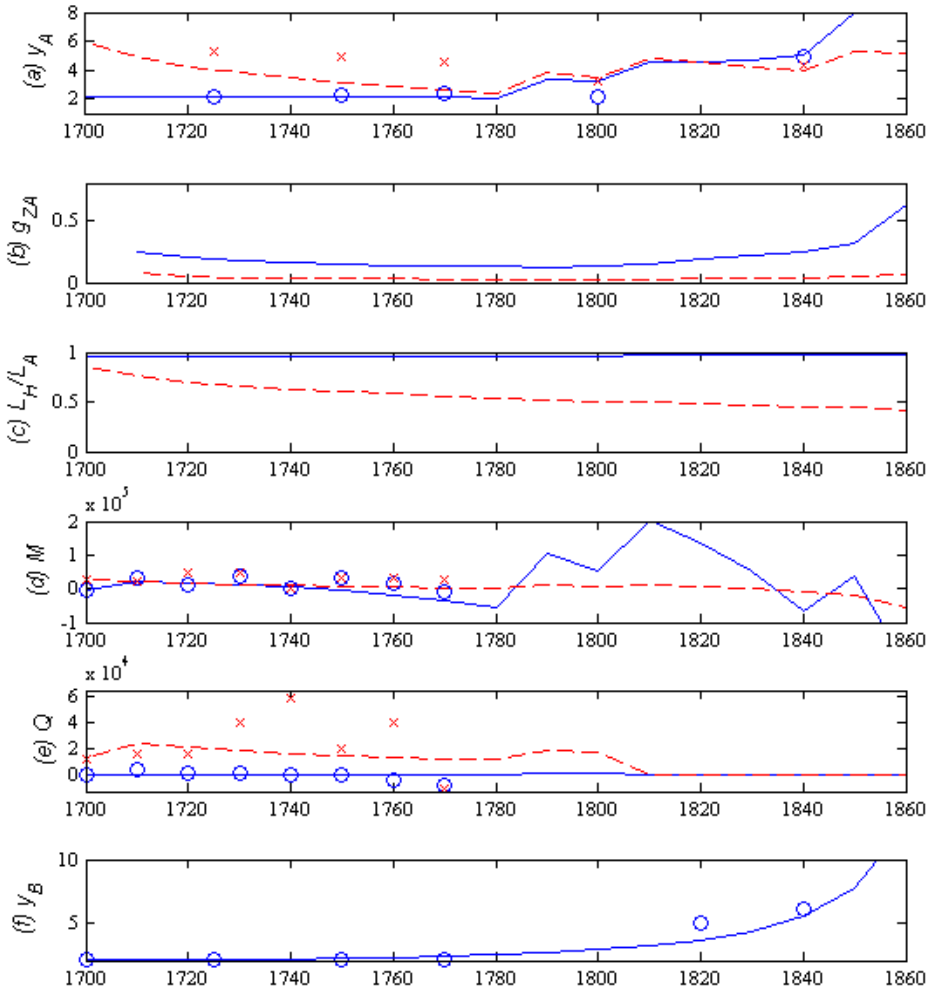
Development paths, the Thirteen Colonies/United States with land acquisition and slavery trade abolition, AD1700-AD1860



Note: Solid (blue) lines: the Thirteen Colonies/United States without slavery trade abolition, parameters from Table 12, except $f = 0.0000226$ for all periods. Dashed (red) lines: the Thirteen Colonies/United States with slavery trade abolition, parameters from Table 12. The panels show evolution of (a) per capita income in the colony, (b) technology growth rate in the colony, (c) number of White migrants to the colony, and (d) number of Black slaves imported to the colony. (Blue) Dots show the implied data from Tables 2-7.

FIGURE 7

Development paths, US-North and US-South, AD1700-AD1860



Note: Solid (blue) lines: US-North. Dashed (red) lines: US-South, parameters from Table 13. See Figure 4 for labels. (Blue) Dots are the implied US-North data, while (red) crosses are the implied US-South data from Tables 2-7.

FIGURE 8

Breakdown of GeoPopulation-Institution hypothesis

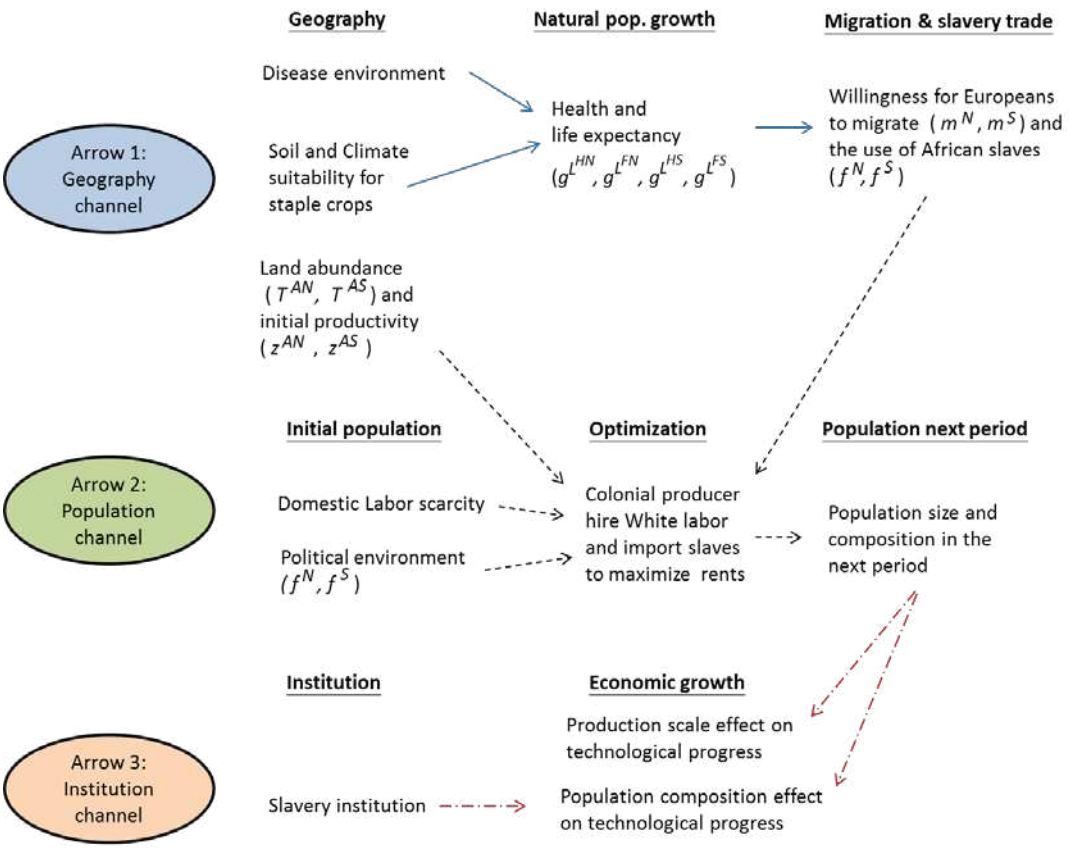
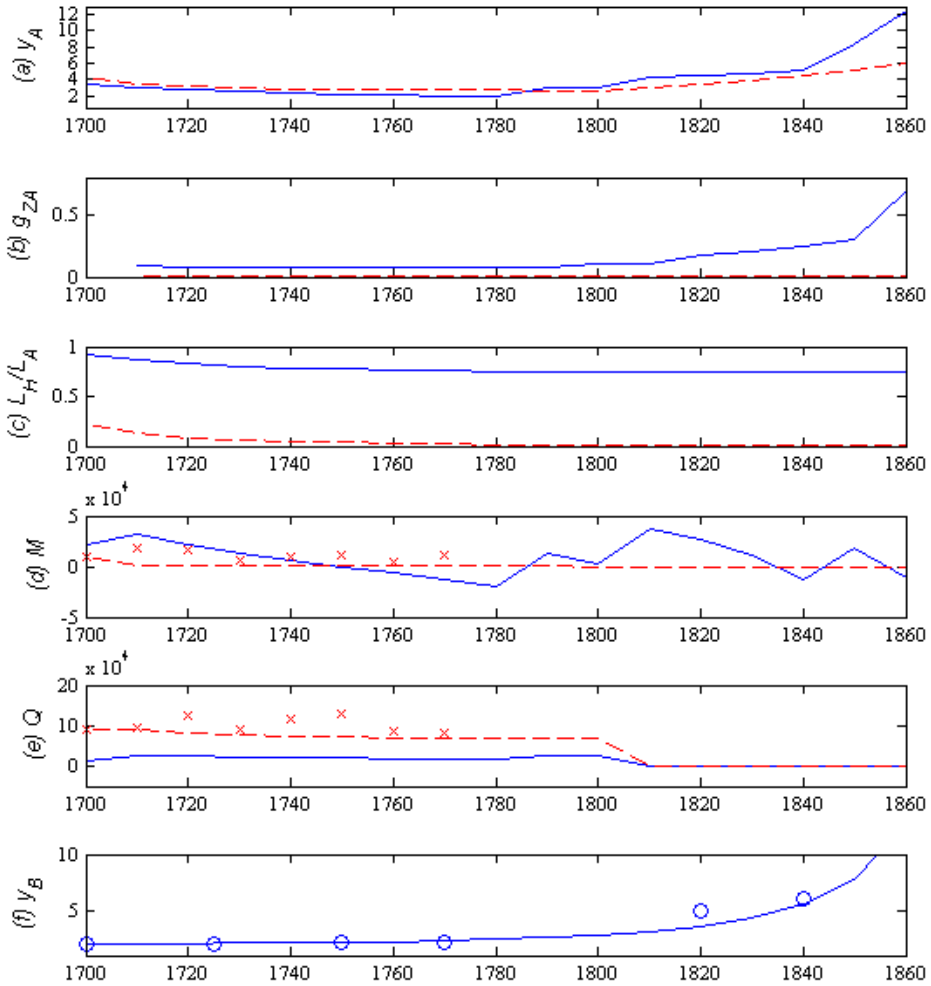


FIGURE 9

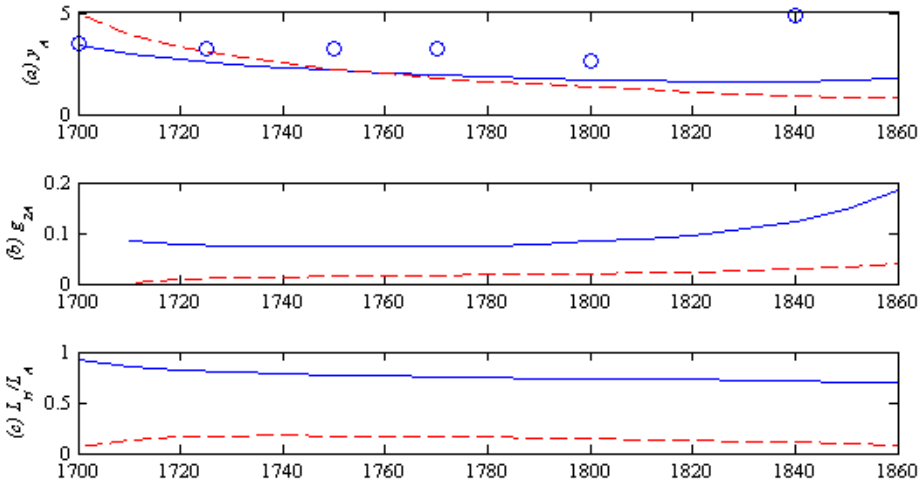
Development paths, the Thirteen Colonies/United States and West Indies, AD1700-AD1860



Note: Solid (blue) lines: the Thirteen Colonies/United States. Dashed (red) lines: West Indies, parameter from Table 14. See Figure 4 for labels. (Blue) Dots are the implied Thirteen Colonies/United States data, while (red) crosses are the implied West Indies data from Tables 2-7.

FIGURE 10

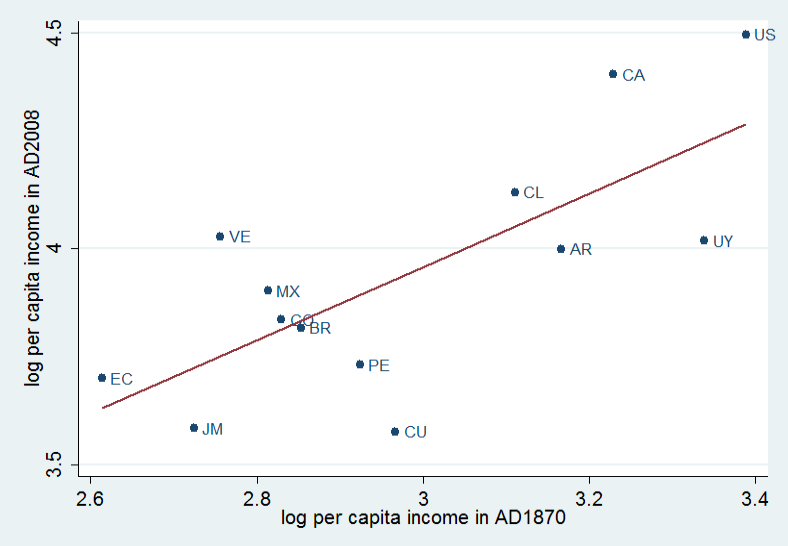
Development paths, "US-type country" and "Spanish-type country", AD1700-AD1860



Note: Solid (blue) lines: "US-type country". Dashed (red) lines: "Spanish-type country", parameter from Table 15. See Figure 4 for labels in panels (a)-(c).

FIGURE 11

Log per capita income in AD2008 against log per capita income in AD1870, American countries



Source: Bolt and van Zanden (2013).

FIGURE A.1

Intertemporal equilibrium with technological improvement in country A