CHAIR ENERGY & PROSPERITY
Energy Transition Pathways and Financing

Working Paper

The occurrence and persistence of the Great Divergence: historians vs. economists' perspectives on growth

Victor Court*

September 2017

Contact: Victor Court, victorcourt@free.fr

* CERES, École Normale Supérieure–PSL Research University, 24 rue Lhomond, 75005 Paris, France ; Chair Energy & Prosperity, Palais Brongniart, 28 place de la Bourse, 75002 Paris, France.

La Chaire Energie et Prospérité

La chaire Energie et Prospérité a été créée en 2015 pour éclairer les décisions des acteurs publics et privés dans le pilotage de la transition énergétique. Les travaux de recherche conduits s'attachent aux impacts de la transition énergétique sur les économies (croissance, emploi, dette), sur les secteurs d'activité (transport, construction, production d'énergie, finance) et aux modes de financement associés. Hébergée par la Fondation du Risque, la chaire bénéficie du soutien de l'ADEME, d'Air Liquide, de l'Agence Française de Développement, de la Caisse des Dépôts, de Mirova, de Schneider Electric et de la SNCF.

Les opinions exprimées dans ce papier sont celles de son (ses) auteur(s) et ne reflètent pas nécessairement celles de la Chaire Energie et Prospérité. Ce document est publié sous l'entière responsabilité de son (ses) auteur(s).

Les Working Papers de la Chaire Energie et Prospérité sont téléchargeables ici :

http://www.chair-energy-prosperity.org/category/publications/

Chair Energy and Prosperity

The Energy and Prosperity academic Chair was created in 2015 to inform decisions of public and private actors in managing the energy transition. The Chair research deals with the impacts of energy transition on national economies (growth, employment, debt), on specific sectors (transportation, construction, energy, finance) and with the associated financing issues. Hosted by the Risk Foundation, the chair has the support of ADEME, Air Liquide, the French Development Agency, the Caisse des Dépôts, Mirova, Schneider Electric, and SNCF.

The opinions expressed in this paper are those of the author(s) and do not necessarily reflect the position of Chair Energy and Prosperity. It is therefore published under the sole responsibility of its author(s).

Working Papers from the Chair Energy and Prosperity can be downloaded here:
http://www.chair-energy-prosperity.org/en/category/publications-2/

The occurrence and persistence of the Great Divergence: historians vs. economists' perspectives on growth

Victor COURT [a,b]

[a] *CERES, École Normale Supérieure–PSL Research University, 24 rue Lhomond, 75005 Paris, France*
[b] *Chair Energy & Prosperity, Palais Brongniart, 28 place de la Bourse, 75002 Paris, France.*

Abstract

The economic Great Divergence among regions and countries of the world that occurred approximately two hundred years ago, and the persistence of this phenomenon over time, are the deepest mysteries of history and economics. The present article contributes to the literature on the Great Divergence by providing a comprehensive review of all deep-rooted and proximate causes of economic growth in a unique document. First, the different deep-rooted causes of economic growth (biogeography, culture, institutions, and contingency/conjuncture) invoked by historians to explain the Great Divergence are synthetically, yet precisely, analyzed. The attention then turns to proximate causes of growth (labor, physical and human capital accumulation, technological progress and its diffusion, and international trade) that economists study through theoretical and econometric models. The paper concludes that deep-rooted factors are effective in a certain context so that their long-lasting effect does not imply an absolute once-and-for-all determinism. Hence, biogeography, culture, institutions, and contingency have all had a relatively higher importance at a given moment, but none of these factors uniquely determined the course of the Great Divergence. Furthermore, theoretical and econometric studies have surely improved the understanding of modern economic growth and the reasons behind the persistence of the Great Divergence (e.g., institutional barriers to technology diffusion, the mismatch between technological needs of developing countries and the world technology frontier).

Keywords: Long-term economic growth, Great Divergence, deep-rooted causes, proximate causes.

JEL Classification: N1, O1, O3, O4.

1. Introduction

1.1 The occurrence and persistence of the Great Divergence

Approximately two hundred years ago, some regions in Western Europe and North America underwent an Industrial Revolution that launched them on an early take-off towards modern economic standards. Other world regions have had a delayed take-off and are catching up more or less rapidly (respectively Eastern Asia, South and Central America on the one hand, Africa and South Asia on the other). The differential timing of the take-off from near-stagnation to sustained economic growth among regions of the world and the associated variations in the timing of their demographic transitions has led to the phenomenon called the *Great Divergence*.

Moreover, it is one thing to observe an association between the beginning of industrialization and the *occurrence* of the Great Divergence, but it is quite another thing to see a *persistence* of this phenomenon over time. As a matter of fact, the spread of GDP per capita between the richest and the poorest world regions (Western Offshoots and Africa respectively) has widened considerably from a modest ratio of 3:1 in 1800 to an impressive 18:1 in 2000 (Figure 1). More precisely, global inequality measured by average national income per capita has increased continuously during the last two hundred years, seems to have peaked around 2000, and has remained stable since (Milanovic 2011; 2012).[1]

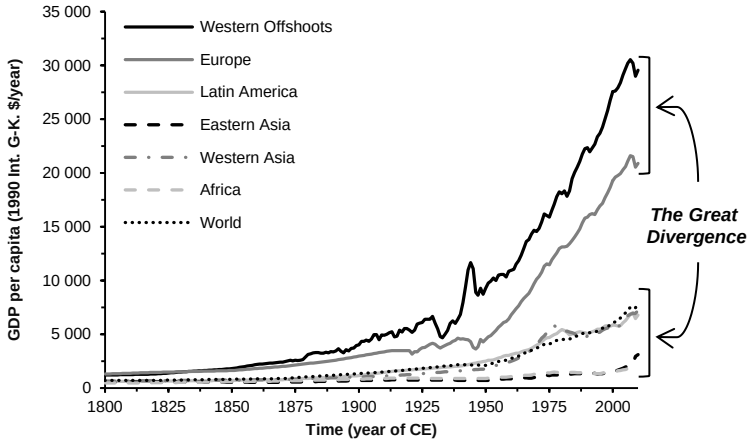

Figure 1. The Great Divergence across regional GDP per capita, 1800–2010 CE.[2]
Data source: The Maddison Project (2013).

1.2 Deep-rooted historic vs. proximate economic causes of growth

Quite logically, scholars in economic history and economics do not tackle the issue of the Great Divergence from the same perspective, both regarding temporality and methodology. Economic historians are more interested in the occurrence of the Great Divergence, for which they used to appeal more or less exclusively to either one of the three following *deep-rooted* cause: biogeography, culture,

[1] Moreover, national average comparison is one concept for assessing global inequality, taking into account within-country inequalities is another. In this case, world distribution of income worsened from the early nineteenth century up to World War II and after that seems to have stabilized or to have grown more slowly (Bourguignon & Morrisson 2002), up to the point that global inequalities among citizens of the world appear to have been stable in the last decade (Milanovic 2012).

[2] CE is an abbreviation for "Common/Current Era" and BCE is an abbreviation for "before the Common (or Current) Era". The CE/BCE designation uses the same numeric values as the traditional Anno Domini (AD) year-numbering system introduced by the sixth-century Christian monk Dionysius Exiguus, intending the beginning of the life of Jesus to be the reference date (hence dates before are labeled "Before Christ", i.e. BC). The two notations, CE/BCE and AD/BC, are numerically equivalent and neither includes a year zero. Thus "2010 CE" corresponds to "AD 2010", and "10,000 BCE" corresponds to "10,000 BC".

or institutions. More recent syntheses try to blend those primary determinants with historical contingency, accidents, and conjuncture to explain the occurrence and the persistence of the Great Divergence.

Relying more on quantitative assessments, the work of economists tend to focus on theoretical econometric models able to explain recent economic growth patterns, and in particular the persistence of the Great Divergence rather than its occurrence. In such theoretical models, *proximate* causes of growth consist in the accumulation of factors of production (labor, physical and human capital) combined with technological change. The international diffusion of technology, financial assets, and commodities also shape the possibility of economic output in such models.

1.3 Missing perspective, goal, and organization of the paper

Despite tremendous efforts, the phenomenon of Great Divergence remains the deepest mystery in history and economics. Knowledge of this phenomenon is now widespread in thousands of articles and hundreds of books, which imply an increasing difficulty for scholars to retain an accurate "big picture" of the problem, and a potential feeling of despair for novices who wish to start their inquiry of this master enigma. Furthermore, given the profusion of hypotheses and analyses that exist to explain the Great Divergence, it seems necessary to make a clearer distinction between the most and the least pertinent of all deep-rooted and proximate explanations of economic growth.

Accordingly, the purpose of the present article is to provide a comprehensive literature review of all deep-rooted and proximate causes of economic growth. To the author's knowledge, this has never been done so far in a single article, which justifies the contribution of the present article to the literature on long-term economic growth. By synthesizing the widespread knowledge of scholars on the occurrence and persistence of the Great Divergence in a single document, the present work should help to frame future discussions on this major subject.

The different deep-rooted causes of economic development for which qualitative and quantitative arguments exist will be synthetically, yet precisely, analyzed in Section 2. The various theoretical frameworks and empirical studies assessing the role of proximate causes of growth will be reviewed in Section 3. Finally, a summary of the contributions of this article will be given in Section 4, along with recommendations for future research.

2. Deep-rooted causes of economic growth: increasing probability in a contingent world

This section reviews the four major deep-rooted causes of long-term economic growth. For each of these four hypotheses (biogeography, culture, institutions, and contingency/conjuncture) some arguments concern the occurrence of the Great Divergence, but others regard the persistence of this phenomenon. To ease the reading, Table 1 summarizes the different deep-rooted causes of growth defined and discussed in the present section.

Table 1. Factors studied as deep-rooted causes of growth in Section 2.

Factors studied as deep-rooted causes of growth	Most important associated references
Biogeographical hypothesis	
Local climate and diseases	Kamarck (1976), Bloom & Sachs (1998)
Sea access and continental openness	Bloom & Sachs (1998), Gallup et al. (1999)
Timing of the agricultural revolution	Diamond (1997), Olsson & Hibbs (2005), Ashraf & Galor (2011)
Cultural hypothesis	
Protestant work ethics	Weber (1930), Cantoni (2015), Becker & Woessmann (2009)
Rise of modern science	Lipsey et al. (2005), Goldstone (2009), Mokyr (2011)
Religion, religiosity, and their effect on trust	Barro & McCleary (2003), Guiso et al. (2003)
Ethnic, linguistic, and religious fractionalization	Easterly & Levine (1997), Collier (2000), Alesina et al. (2003)
Genetic and cultural co-evolution	Clark (2007), Spolaore & Wacziarg (2009), Ashraf & Galor (2013)
Institutional hypothesis	
Political and economic institutions (theory)	North (1990), Greif (2006), Acemoglu & Robinson (2012)
Inclusive institutions enable growth (evidence)	Acemoglu & Robinson (2012), Mokyr (2011)
Exclusive institutions preclude growth (evidence)	Acemoglu et al. (2001), Kuran (2012)
Contingency, accidents, and conjuncture hypothesis	
Divided European nations vs. unified Chinese empire	Wong (1997), Pomeranz (2000), Hoffman (2015)
Relative ocean sizes and Atlantic trade	Pomeranz (2000), Morris (2010)
Crucial role of coal	Allen (2009), Wrigley (2013), Kander et al. (2014)

2.1 Biogeographical hypothesis

The biogeographical hypothesis contains three variants: (i) the long-lasting effect of local climate (temperature, humidity, rainfall, diseases prevalence) on economic development; (ii) the incidence of natural endowments in terms of sea access and overall openness of continents; (iii) the timing of the agricultural revolution and its impact on pre-modern advancements.

2.1.1 Local climate and diseases

Theories belonging to this hypothesis suppose that favorable biogeographical conditions fostered the earlier Western European take-off and explained the divergence in income per capita around the globe. Such socio-political-environment theory can be found in Marshall (1890, p.195) and Toynbee (1934), but it is Machiavelli ([1517] 1998) and Montesquieu (1748) who proposed its original version. The basic idea of this hypothesis is that hot and wet climates are detrimental to hard work and creativity, and furthermore imply little effort in providing shelter and gathering food, whereas cold and dry climates are conducive to, and necessarily require much more work and ingenuity.

Quite similarly, Kamarck (1976, p.11) stresses that climatic factors have hampered economic development in today's developing countries through their impact on agriculture (directly or through the diseases and pests afflicting animals and plants), mineral discovery, and human man diseases. Bloom & Sachs (1998) detail these points and argue that in Africa in particular, tropical agriculture is faced with chronic problems of low yields and fragility due to low photosynthetic potential, high evapotranspiration, low and variable rainfall, highly weathered soils, veterinary diseases, and plant and

animal pests. For these authors, evidence suggests that the burden of infectious disease (particularly malaria) is vastly higher in the tropics than in the temperate zones.

2.1.2 Sea access and continental openness

Quite differently, Braudel (1996 [1949]) emphasizes the key role of Mediterranean and North Atlantic coastal countries as the creative centers of global capitalism after the fifteenth century. McNeill (1963) and Crosby (1986) similarly stress Europe's significant advantages in coastal trade, navigable rivers, temperate climate, and disease patterns as key conditions for its take-off and eventual domination of the Americas and Australia.

Furthermore, Bloom & Sachs (1998) support econometrically that the failure of Africa to control diseases is not mainly the result of poor public health measures, unresponsive governments, or poverty, but it is rather due to the natural environment. Finally, to explain the long-term development lag of Africa, these authors point to five remarkable disadvantages in transport costs: (i) a great distance from major world markets in the northern mid-latitudes, in particular the separation from Europe by the vast Sahara desert; (ii) a very short coastline relative to the land area; (iii) very few natural coastal ports; (iv) the highest proportion of landlocked states, and the largest proportion of the population within landlocked states, of any continent; and (v) the absence of rivers leading into the interior of the mainland that are navigable by ocean-going vessels, as are the Rhine, the Mississippi, the Amazon, and the Yangtze on other continents.

The statistically significant impact of geographical endowment (through climate and land openness) on per capita GDP growth is even more consistently demonstrated by Gallup et al. (1999). These authors conclude that sub-Saharan Africa is especially hindered by its tropical location, the high prevalence of malaria, a small proportion of people living near the coast, and low population density near the coast. Europe, North America, and East Asia, by contrast, have been favored on all four counts according to these authors.

2.1.3 Timing of the agricultural revolution

Diamond (1997) proceeds to a backward induction reasoning to propose a radically different version of the biogeographical hypothesis. According to him, if Western Europe rules (for now), it is thanks to advantages in technology (guns, large sail ships, higher disease resistance) and institutions (large markets, political organization, property right protection) that were already present or on the verge to be established circa 1500 CE. Those advantages explain that Westerners colonized the New World (and not the other way around) and that they were then the first to launch the Industrial Revolution. Diamond asserts that if Westerners had such large technological and institutional advantages circa 1500 CE, it is because Western Eurasia was the first world region to experience the Agricultural Revolution of the Neolithic with several millennia of advance compared to other continents. Hence, Western Eurasia was the first region to benefit from the early establishment of cities, writing, high population densities, and associated non-food producing elites that created and organized knowledge.

As the author then argues, if agriculture first emerged in the Hilly Flanks of Southwest Asia and then easily spread to Western Europe and the rest of Eurasia, it is not because their inhabitants were cleverer and better adapted to their environment, it is just because their environment offered them a higher number of suitable plants and animals for domestication. For example, of the 56 wild large-seeded grass species of the world, 32 were present in the Mediterranean region, whereas East Asia only had 6, Mesoamerica 5, Sub-Saharan Africa 4, and South America and Oceania 2. Similarly, out of the world's 14 domesticated herbivorous mammals weighing more than 45 kg and hence adapted to agricultural work, 13 were in Eurasia, only 1 in South America, and 0 in Africa and Oceania. According to Diamond, with such an uneven distribution of wild plants and animals suitable for domestication, the differential timing of the agricultural onset in different regions of the world was not completely

predetermined, but it could hardly have been different.[3] Hence, the earlier onset of agriculture in Southwestern Asia and its rapid diffusion to Europe was a matter of higher probability. Domesticated plants and animals gave first to Western Eurasia a reliable source of food with high nutritional value, but also fertilization, wool, leather, transport, plowing, and military power that could feed a much greater population per unit area and consequently sustain an increasing proportion of non-food-producing but technology-inventing population. Moreover, the close physical proximity of man and animal also gave Eurasian agriculturists a high resistance to animal-related germs such as those causing smallpox, measles, and tuberculosis. The absence of an equivalent resistance to animal-related germs in America proved to be decisive during the colonization of the New World since germs brought from Europe killed more Native Americans than guns and swords. As shown in Figure 2 where the technological and organizational trajectories of the different regions of the world are represented, the head start of Western Eurasia lasted for millennia and was slow to resorb.

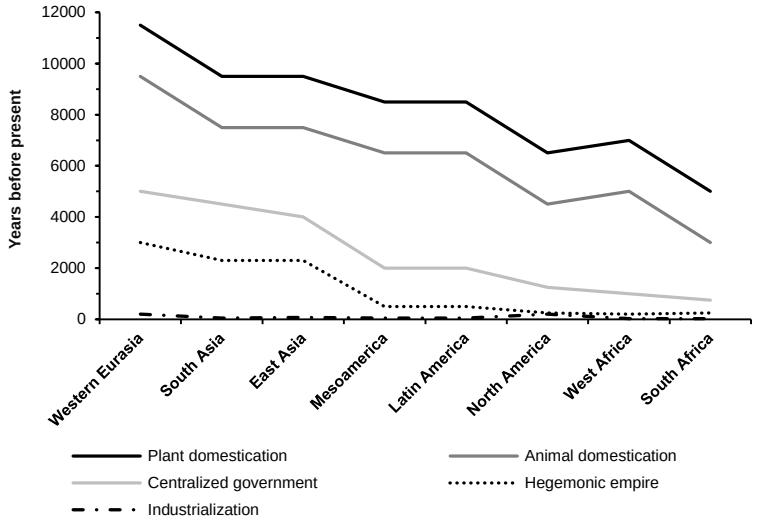

Figure 2. Development trajectories of different world regions, 10,000 BCE–2000 CE.
The flatter the line, the smaller the technological and organizational gaps between regions, the more uniform the world.
Source: reproduced from Morris (2015, p.153).

Two econometric studies support Diamond's thesis. Olsson & Hibbs (2005) show that the unequal distribution of domesticable plants and animals accounts for around two-thirds of the regional variation in the estimated dates of the agriculture onset. These authors further show that exogenous geography (continental size and axis, climate, latitude) and initial biogeographical conditions (number of domesticable plants and animals) account for half of the sixty-fold difference in contemporary per

[3] The reasons for the unequal distributions of domesticable plants and animals across world regions are numerous. First, Eurasia is the largest terrestrial continent, so that other things being equal its biodiversity should be higher than other continents such as Africa, America and Oceania. Second, regarding plants, the temperate climate around the Mediterranean Sea has surely been influential in favoring large-seeded grass species compared to the equatorial and tropical climates of Sub-Sharan Africa, Mesoamerica, and South America. Third, the East–West orientation of Eurasia compared to the North–South orientation of America and Africa implied that agricultural technologies spread more easily among Eurasian regions of similar climate compared to the more heterogeneous climatic regions of other continents that were moreover endowed with a higher number of natural barriers (desert, dense forests, and terrestrial bottlenecks such as the Isthmus of Panama). .Fourth, concerning large mammals, Martin (1984) posits that the later *Homo sapiens* reached various regions, the greater was their skill as big game hunters and the less experience their prey had with human predators, which resulted in the rapid extinctions of large animals in the Americas and Australia in the late Pleistocene (see Grayson (1991) for the alternative climate change related hypothesis of the Pleistocene megafauna extinction in America and Oceania). Olsson & Hibbs (2005) have indeed shown that exogenous geographic conditions (climate, latitude, continental axis and size) explain around 80% of the variance of the international distribution of heavy seeded plants and large domesticable animals that are known to have existed in prehistory.

capita income observed in a broad international cross-section of 112 countries. These results indicate that current variations in economic prosperity still significantly embody the effects of prehistoric biogeographical conditions. More recently, Ashraf & Galor (2011) found a highly statistically significant positive effect of regional differences in land productivity and the number of years elapsed since the Neolithic Revolution on local population density in the years 1 CE, 1000 CE, and 1500 CE. However, according to these authors, the effects of land productivity and the number of years elapsed since the Neolithic Revolution on the per capita income of the same periods are not significantly different from zero,[4] which contradicts the results of Olsson & Hibbs (2005) on this point.

As noted by Acemoglu & Robinson (2012, p.52), although Diamond's argument, and to a lesser extent other versions of the biogeographical hypothesis, are compelling explanations for intercontinental differential developments, they can hardly elucidate the current level of economic inequality between countries of the same world region. In other words, although the endowment of biogeographical factors has surely had a significant effect on long-term economic development, the interplay of other factors is needed to have a comprehensive explanation of the economic growth process.

2.2 Cultural hypothesis

The cultural hypothesis regroups four different sub-hypotheses: (i) the Protestant work ethics as an enabler of modern development; (ii) the rise of modern science in Western Europe as a prerequisite for the Industrial Revolution; (iii) the impact of religious dogmas and religiosity on economic growth; (iv) the long-lasting influence of the genetic composition of populations on their cultural characteristics and their consequences on the comparative economic performances of societies.

2.2.1 Protestant Reformation and the Protestant work ethics

Jones (1981) and Landes (1998) are usually said to be the main proponents of the cultural hypothesis among contemporary scholars.[5] Landes judgment is that "if we learn anything from the history of economic development, it is that culture makes all the difference. (Here Max Weber was right on.)" (Ibid., p.516).[6] Landes refers to the popular theory of Weber (1930 [1905]) stressing that the Protestant Reformation and the Protestant work ethic it spurred in the sixteenth century played a key role in the rise of a modern industrial society in Western Europe. Weber argues that contrary to Catholicism, Protestantism defines and sanctions an ethic of everyday behavior that is conducive to business success because the Protestant work ethic makes people work harder, more efficiently, and is akin to entrepreneurship. In addition to qualitative rebuttals (Tawney 1926; Samuelsson 1961), econometric studies seem unable to concretely support the Weberian Protestant work ethic theory (Arruñada 2010; Cantoni 2015). However, another point made by Weber was that the Protestant Reformation narrowed the gender gap in school enrollment and literacy rates. Not surprisingly, this social aspect of Weber's theory has found much more support among economists (Becker & Woessmann 2009; 2010; Schaltegger & Torgler 2010) who usually put much emphasis on human capital accumulation to explain the economic growth process as will be seen in Section 3.2.

Following the same line of thought, some early scholars have closely tied the Protestant Reformation to the rise of modern science. De Candolle (1885) counted that of the ninety-two foreign

[4] Importantly, the qualitative results remain robust to controls for the effects of a large number of geographical factors, including absolute latitude, access to waterways, distance to the technological frontier, and the share of land in tropical versus temperate climatic zones, which may have had an impact on aggregate productivity either directly, by affecting the productivity of land, or indirectly via the prevalence of trade and the diffusion of technologies.

[5] However, with his more recent book Ferguson (2011) is probably a serious contender for such title.

[6] It would be unfair to say that Landes thinks that culture alone explains all the differences among countries' abilities to generate wealth. In his own words (p.517), "economic analysis cherishes the illusion that one good reason should be enough, but the determinants of complex processes are invariably plural and interrelated".

members elected to the French *Académie des Sciences* in the period 1666–1866, some seventy-one were Protestant, sixteen Catholic, and the remaining five Jewish or of indeterminate religious affiliation, this from a population pool outside of France of 107 million Catholics and 68 million Protestants.[7] Merton (1938) focused on English Puritanism and German Pietism as being responsible for the development of the scientific revolution of the seventeenth and eighteenth centuries. According to this author, Protestant values encouraged scientific research by allowing science to identify God's influence in the world and thus providing religious justification for scientific research.

2.2.2 Rise of modern science

Lipsey et al. (2005, p.225–289) propose a deeper origin to the very same argument. They stress that the roots of mechanistic science in Western Europe lay in the last half of the medieval period which saw the development of pluralistic societies that ultimately freed natural philosophers to pursue a uniquely powerful form of science seeking an explanation of the world in mechanical laws. These authors also assert that the absence of early economic takeoff in China and advanced Islamic countries is explained by the failure of these countries to develop anything like modern science because of inappropriate institutions lay down in part by their religious dogmas and monolithic state structures. In particular, it is argued that Islam is an occasionalist doctrine in which the state of the world at any one moment in time is contingent on the particular will of God. On the contrary, the doctrine of Christian naturalism posits that God created the world according to natural laws and then endowed humans with free will to determine their own affairs. For Lipsey et al. (2005) this difference was decisive to see the apparition of science in early modern Europe whereas Islam developed hostility against free inquiry and mechanistic science. Moreover, according to these authors, the incapacity of China to develop an original version of modern science on its own has more to do with the absence of institutions that would save and organize cumulative knowledge, whereas on the contrary Europe elaborated an early institutionalization of scientific research through universities and scientific societies.

Other eminent scholars such as Jacob (1997), Goldstone (2009) and Mokyr (2011) also attribute much of the credit for the burst of innovations and accelerated diffusion of best practices after 1750 to the scientific culture of Western Europe, and in particular Britain. They argue that Western European societies were particularly dynamic and inclined to see a technological breakthrough in the eighteenth century thanks to the increase, or propagation during the previous two hundred years, of printing books, publishers, scientific societies, university networks, relatively accessible public lectures, and growing day-to-day exchanges between scientists, engineers, and artisans. The argument is thus that only Britain had a mechanical science that permeated the whole society enabling a unique ability to convert ideas and inventions (that often came from other European countries such as France, the Netherlands or Germany) into workable innovations that rapidly transformed into useful technologies yielding profits to their developers. For all these authors, changes in the intellectual and social environment and the institutional background in which knowledge was generated and disseminated from the sixteenth to the eighteenth centuries explain the success of the British Industrial Revolution. It is important to understand that all these scholars do not denigrate the many scientific breakthroughs that episodically originated in China and Islamic countries. They rather highlight the earliness of Britain in creating a scientific culture able to transpose useful knowledge into technological change thanks to a favorable institutional environment.[8]

[7] A count of foreign fellows of the Royal Society in London in 1829 and 1869 showed similar relative proportions of Catholics and Protestants out of a pool in which Catholics outnumbered Protestants by more than three to one (de Candolle, 1885).

[8] It must be noted that assigning the above emphasis of modern science development to the cultural hypothesis rather than the institutional hypothesis of the coming section 2.3 is quite arbitrary given its clear reliance on institutional change. We shall return later in this article to the obvious overlapping and feedback relation existing between cultural and institutional change.

2.2.3 Trust, religion, and religiosity

So far the notion of culture has not received a formal definition, but such a task is required when it comes to seeing how econometric studies can support the cultural hypothesis, in particular, to explain the persistence of the Great Divergence. Guiso et al. (2006, p.23) define culture as "those customary beliefs and values that ethnic, religious, and social groups transmit fairly unchanged from generation to generation." Because such a definition of culture is hardly quantifiable, culture entered the economic discourse mainly through the concept of trust, defined by Gambetta (1988, p.217) as "the subjective probability with which an agent assesses that another agent or group of agents will perform a particular action." Several econometric studies (Knack & Keefer 1997; Zak & Knack 2001) demonstrate that trust and civic cooperation have a significant positive correlation with aggregate economic activity.

Regarding religion, Barro & McCleary (2003) show that for given religious beliefs, increases in church attendance tend to reduce economic growth. In contrast, for given levels of church attendance, increases in some religious beliefs, notably belief in hell, heaven, and an afterlife, tend to increase economic growth. Barro & McCleary's (2003) conjecture is that stronger religious beliefs stimulate growth because they help sustain specific individual behaviors (such as honesty, a work ethic, frugality, trust, and openness to strangers) that enhance aggregated economic productivity. Moreover, Guiso et al. (2003) show that being raised religiously raises the level of trust by two percent, whereas regularly attending religious services increases trust by another twenty percent compared to nonreligious people. Furthermore, Guiso et al. (2003) find that on average Christian religions are more positively associated with attitudes that are conducive to economic growth (trust in others and the legal system, respect for women rights), while Islam is negatively associated. Between the two most prominent Christian denominations, Protestant and Catholics, the ranking is less clear. It appears that Protestants trust others and the legal system more than Catholics, and they are less willing to cheat on taxes and accept a bribe. By contrast, Catholics support private ownership twice as much as Protestants and are more supportive of competition than any other religious group (including Protestants).

2.2.4 Ethnic, linguistic, and religious fractionalization

Another significant body of studies of the cultural hypothesis concerns the impact of the level of ethnic, linguistic and religious fractionalization on economic growth. Knack & Keefer (1997) have shown that trust and norms of civic cooperation (that positively affect economic growth) are stronger in countries that are less polarized along the lines of class or ethnicity. Similarly, Easterly & Levine (1997) assert that cross-country differences in ethnic diversity are positively correlated with a substantial part of the cross-country differences in public policies, political instability, and other economic factors associated with long-run growth.

Arcand et al. (2000) harshly criticize the methodology employed by Easterly & Levine (1997), while Alesina et al. (2003) nuance their results. The latter explain that ethnic and linguistic fractionalization variables are likely to be important determinants of economic success, but that strong correlation with other potential variables, geographical ones in particular, greatly complicates the evaluation of the size of these effects. Collier (2000) and Alesina & La Ferrara (2005) argue that fractionalization has adverse consequences on growth and productivity only in nondemocratic regimes, while democracies manage to cope better with ethnic diversity.

2.2.5 Genetic and cultural co-evolution

Another recent set of publications goes deeper to explain the phenomenon of Great Divergence through culture as they explore the long-lasting influence of the genetic composition of populations on their cultural characteristics and their consequences on the comparative economic performances of societies. Clark (2007) proposes that Darwinian natural selection of the fittest (in his view the richest) endowed with growth-compatible characteristics (entrepreneurial and hard-working spirits, patience and

innovativeness) can explain the phenomenon of Great Divergence, on the (unexplained) premise that such a natural selection was more active in England than in the rest of the world during the centuries preceding the Industrial Revolution.

An alternative view is proposed by Spolaore & Wacziarg (2009) who assert that "genetic distance", a measure associated with the time elapsed since two populations' last common ancestors, has a statistically and economically significant effect on income differences across countries (even controlling for measures of geographical distance, climatic differences, transportation costs, and measures of historical, religious, and linguistic distance). The authors provide an economic interpretation of these findings in terms of barriers to the diffusion of development from the world technological frontier (a subject we shall return to in Section 3.4), implying that income differences should be a function of relative genetic distance from the world technology frontier.

Another explanation of the causal effect of the genetic material on differential economic performance was advanced by Ashraf & Galor (2013). Using data on genetic diversity from the 53 ethnic groups across the globe that constitute the Human Genome Diversity Cell Line Panel, these authors show that migratory distance from East Africa has an adverse effect on genetic diversity so that genetic diversity is higher for natives of Africa, lower for natives of Asia, Oceania, and South America, and intermediate for natives of Europe. To the authors' mind, genetic diversity is both negatively associated with the extent of cooperative behavior as it raises the likelihood of disarray and mistrust, and positively related to innovative activity, as measured by the intensity of scientific knowledge creation. Hence, for Ashraf & Galor the degree of diversity in a society may provide a wider spectrum of traits that are complementary to the implementation of advanced technological paradigms (possibility of expanding the society's production frontier), but it may also reduce trust, cooperation and hence the efficiency of the production process. In support of their theory, Ashraf & Galor obtain a hump-shaped relationship (i.e., an inverted U curve) when population density in 1500 CE, or the level of income per capita in 2000 CE,[9] is plotted as a function of genetic diversity.[10]

If the interaction between genetic and cultural evolution has been intensively explored since the 1980s (recent references include Richerson & Boyd (2005) and Jablonka & Lamb (2014)), additional research is needed to precise the complex relations existing between genetic and cultural intergenerational transmission of traits on the one hand, and economic outcomes on the other (see the complementary literature reviews of Spolaore & Wacziarg 2013; Collins et al. 2016; and Ashraf & Galor 2017). It is worth mentioning that, as could have been expected, these recent works on the relationship between the genetic composition of populations and comparative economic performance of societies have triggered a vibrant debate which shall not be further investigated in the present article for the sake of brevity.[11]

2.2.6 Culture or institutions?

As can be seen in this literature review, the problem with the cultural hypothesis lies in the difficulty of establishing a straightforward causal link between core beliefs and preferences on the one

[9] Recall that levels of most advanced development are marked by higher population density in pre-industrial societies, whereas higher GDP per capita is acknowledged as a better definition of higher development in modern economies.

[10] These hump-shaped impacts seem robust to controls for the fixed effect of geography, disease environments, ethnic fractionalization, various measures of institutional quality, major religion shares, the share of the population of European descent, and years of schooling.

[11] Benjamin et al. (2012) is among the first reflections on the promises and pitfalls of this emerging field of research baptized *Genoeconomics*. Among dozens of (generally positive) reviews, the evolutionary theory of Clark (2007) has come in for particularly vigorous criticism from four referees (McCloskey 2008; Voth 2008; Grantham 2008; Persson 2008) to which Clark gave a published response (see Clark 2008). The work of Ashraf & Galor (2013) received extremely harsh criticisms from a team of anthropologists (Guedes et al. 2013) to which a response was given in an open letter available online (see Ashraf & Galor 2014).

hand, and economic performances on the other. Aside from the highly persuasive argument of scholars who assert that the Scientific Revolution and the associated development of mechanistic science was an absolute prerequisite for the Industrial Revolution, all other arguments emphasizing the role of cultural traits (be it religious beliefs, linguistic and ethnic particularities or their levels of fractionalization, etc.) are hardly supported by compelling empirical evidence. Indeed, all econometric results previously cited are based on multiple linear regressions (that most of the time use proxies to control for geographical and institutional factors, and physical and human capital accumulation) and hence represent correlations but not causal relations between cultural traits and economic growth.

Two reasons might preclude a direct causal relation from culture to economic growth. First, the endogenous nature of culture implies that, despite its significant path-dependency (i.e., the fact that culture is a historical heritage) and the various impacts that cultural aspects can have on growth, economic development is surely associated with shifts toward values that are increasingly rational, tolerant, trusting, and participatory (Inglehart & Baker 2000). Second, numerous scholars have claimed that culture does not directly affect economic growth, but instead plays an indirect role through institutions (Todd 1983; Greif 1994; Guiso et al. 2004), and probably as many researchers have argued on the contrary that institutions shape cultural traits (Alesina & Fuchs-Schündeln 2007; Grosjean 2011; Nunn & Wantchekon 2011). Common sense suggests that culture and institutions are connected through a feedback relation, which is not surprising given the blurred and overlapping definitions of these two concepts.

2.3 Institutional hypothesis

The institutional hypothesis is by far the most appreciated hypothesis of economists. As such, a precise definition of political and economic institutions deserve some space in this section. Moreover, stating the difference between *inclusive* and *exclusive* institutions is crucial for this hypothesis to make sense. After developing these theoretical explanations, this section ends with the presentation of empirical evidence consisting mainly in historical narratives.

2.3.1 Defining institutions

Building on North & Thomas (1973), North (1990, p.3) defines institutions as "the rules of the game in a society or, more formally the humanly devised constraints that shape human interactions. In consequence, they structure incentives in human exchange, whether political, social, or economic". However, North further divides institutions into formal constraints (constitutions, rules, laws), informal constraints (norms of behavior, convention, and self-imposed codes of conduct), and their enforcement characteristics. In North's theory, formal rules and their enforcement emanate from the political regime, whereas informal norms "come from socially transmitted information and are part of the heritage that we call culture" (North 1990, p.37). The clear overlap of North (1990)'s definition of institutions with Guiso et al. (2006)'s definition of culture is partly resolved by Acemoglu & Robinson (2012) who define institutions as mechanisms through which social choices are determined and implemented. These authors furthermore distinguish between economic and political institutions, and hence leave to culture the informal constraints of North (1990). In combination with the distribution of economic resources, political institutions determine the distribution of political power across different socioeconomic groups, which in turn shape economic institutions that direct economic performance and resource allocations.

2.3.2 Inclusive vs. exclusive institutions: theory

This synergistic relation between economic and political institutions is enriched by the distinction made by Acemoglu & Robinson (2012) between inclusive and exclusive institutions. Inclusive economic institutions are those that allow and encourage participation by the great mass of

people in economic activities, make the best use of their talents and skills, and enable individuals to make the choices they wish. Examples of economic institutions include secure private property, an unbiased system of law, and a provision of public services that provides a level playing field in which people can exchange and contract. Inclusive institutions must also permit the entry of new businesses and allow people to choose their careers (*Ibid*., pp.74–75). Extractive economic institutions have opposite properties and are designed to extract incomes and wealth from one subset of society to benefit a different subgroup (*Ibid*., p.76). Inclusive political institutions, defined by these same authors as those that are sufficiently centralized and pluralistic, become exclusive when either of these conditions fails (*Ibid*., p.81).[12] The central idea of the institutional hypothesis[13] is that economic growth and prosperity are associated with inclusive economic and political institutions, while extractive institutions typically lead to stagnation and poverty. Hence, for proponents of the institutional hypothesis, the occurrence and persistence of the Great Divergence mainly come from the fact that some nations managed to develop inclusive institutions that fostered economic development whereas others did not.

North (1994, pp.360–361) further emphasizes the idea that institutions are not necessarily or even usually created to be socially efficient; rather they, or at least the formal rules, are set up to serve the interests of those with the bargaining power to create new rules. That is why, Acemoglu & Robinson (2012, pp.372–376) assert that countries become failed states not because of their geography or their culture, but because of the legacy of: (i) extractive economic institutions that do not create the different incentives needed for people to save, invest, and innovate; and (ii) extractive political institutions that concentrate power and wealth in the hands of those controlling the state, opening the way for public investment negligence, unrest, strife, and civil war.

2.3.3. Inclusive vs. exclusive institutions: empirical evidence

To support the institutional hypothesis, Hall & Jones (1999), Knack & Keefer (1995), and Acemoglu et al. (2001; 2002) all use the same data set to report a cross-country relationship between the log of GDP per capita in 1995 and a broad measure of property rights, "protection against expropriation risk", averaged over the period 1985 to 1995. Easterly & Levine (2003) assert that measures of tropics, germs, and crops explain cross-country differences in economic development through their impact on institutions. On the contrary, Rodrik et al. (2004) assert that the quality of institutions (property rights and the rule of law) is far more important for explaining economic growth than geography or trade. As claimed by Glaeser et al. (2004), this lack of consensus can be explained, as in the case of culture, by the fact that such quantitative studies between the quality of institutions and economic growth have two pitfalls: (i) only broad proxies are available to measure explanatory variables (usually a crude measure of property right protection, which is one of the many aspects of the quality of institutions); (ii) econometric regressions can deliver significant correlations but causal relations cannot be formally proved, even when instrumental variables are included. As a consequence of the ineffectiveness of econometric studies, proponents of the institutional hypothesis rely on the narratives of natural experiments to support their theory.[14]

[12] As already said, economic and political institutions interact in strong synergy. For example, "extractive political institutions concentrate power in the hands of a narrow elite and place few constraints on the exercise of this power. Economic institutions are then often structured by this elite to extract resources from the rest of society. Extractive economic institutions thus naturally accompany extractive political institutions. In fact, they must inherently depend on extractive political institutions for their survival. Inclusive political institutions, vesting power broadly, would tend to uproot economic institutions that expropriate the resources of the many, erect entry barriers, and suppress the functioning of markets so that only a few benefit" (Acemoglu & Robinson 2012, p.81).

[13] Without any claim on completeness, other publications and books discussing institutional changes and their relations to economic development in the long-run include: Nelson & Winter (1982), Alston et al. (1996), Williamson (2000), Greif (2006).

[14] Theoretical frameworks have also been developed to analyze the impact of institutions on economic growth, such as (here again without any claim on comprehensiveness): Saint-Paul & Verdier (1993), Alesina & Rodrik (1994), Benabou (2000), and Acemoglu & Robinson (2000; 2006).

The first example of such historical narrative is the contrast existing between the Democratic People's Republic of (North) Korea and the Republic of (South) Korea. As explained by Acemoglu & Robinson (2012, p.70–73), after the second world war South Korea adopted a market economy where private property was recognized whereas dictatorship was established in North Korea with the help of the Soviet Union. Industrial production fails to take off in North Korea, and agricultural productivity collapsed as well in this country. On the contrary, although not fully democratic during its early phases, South Korea managed to take advantage of policies encouraging population education, investment in industrialization, exportations, and the transfer of technology from most developed countries. As a consequence, as one of East Asia's "Miracle Economies," South Korea quickly became one of the most rapidly growing nations in the world, while North Korea became one of the worst places in the world to live.

A second important natural experiment of the institutional hypothesis is European colonialism. Sokoloff & Engerman (2000) developed the idea that the different quality of institutions set up in various European colonies in the fifteenth century may have had a persistent effect on the level of development of countries once they recovered their independence. Based on this idea, Acemoglu et al. (2001) report that in colonies in which Europeans did not settle in large numbers, such as Africa, Central America, the Caribbean, and South Asia, their objective was to oppress the native population and facilitate the extraction of resources in the short run. On the contrary, in colonies where Europeans settled in large numbers, such as the United States, Canada, Australia, and New Zealand, the institutions were being developed for their future benefits, and hence were inclusive. Acemoglu et al. (2001) further show that these different colonization strategies were in part determined by the mortality rates of settlers as they find a significant negative correlation between mortality rates of settlers and the quality of early institutions. Furhtermore, Acemoglu et al. (2002) report that Europeans were more likely to introduce extractive institutions in areas originally more densely populated by natives. Indeed, it was more profitable for them to exploit the indigenous population, either by having them work in plantations and mines, or by maintaining the existing system and collecting taxes and tributes. Finally, Acemoglu et al. (2001) argue that these early institutional differences have had long-lasting effects on present income per capita distribution. They find a significant positive correlation between the quality of early institutions and that of modern institutions, and a significant positive correlation between the quality of modern institutions and income per capita (when controlling for latitude, climate, current disease environment, religion, natural resources, soil quality, ethnolinguistic fragmentation, and present racial composition).

A third important historical experiment documented by Acemoglu & Robinson (2012, p.73, 197, 198, 202) concerns the underlying causes of the British success in leading the Industrial Revolution. They argue that the growth of the Atlantic trade associated with European colonialism that started in the sixteenth century strengthened merchant groups by constraining the power of the European monarchies (up to the overthrow of James II during the English Glorious Revolution). Such changes in relative bargaining powers helped merchants obtain changes in institutions to protect property rights (on land and capital), which paved the way for further innovations in inclusive economic institutions. As a result, English and Dutch merchant nations invested more, traded more, but mostly England develop a particular institutional environment that proved to be decisive to its industrial onset. Indeed, Mokyr (2011, p. 486–487) speaks of the English Parliament as a *meta-institution* which inherent flexibility was and still is, crucial to sustaining economic growth by a continuous adaptation to the changing environment.

Kuran (2012; 2016) develops another historical example supporting the institutional hypothesis when he asserts that Islamic legal institutions, which had benefitted Middle Eastern economies in the early centuries of Islam, then acted as a drag on development by slowing or blocking the emergence of central features of modern economic life. Those traditional extractive economic institutions include: (i)

Islam's original tax system, which failed to protect property rights; (ii) the *waqf* (a non-state institution ruling property donation to the civil society), whose rigidity hampered the development of civil society; and (iii) private commercial enterprises, whose small scales and short lives blocked the development of private coalitions able to bargain with the state. According to Kuran, these extractive institutions contributed to features that sustained autocracies and kept democracies unstable (high corruption, low trust, widespread nepotism and a high tolerance for law-breaking), which has had long-lasting effects on the economic development of the Middle East up to present days.

2.3.4 Reversing the loop

Regarding the colonial experience, Glaeser et al. (2004) claim that Europeans who settled in the New World may have brought with them not so much their institutions, but themselves, that is, their culture and human capital. Hence, Glaeser et al. (2004) suggest that human capital is a more basic source of growth than institutions are. They argue that cases of developing countries escaping poverty through sound policies enacted by dictators exist. The positive economic outcomes of such transition then improve political institutions. Glaeser et al. (2004) recognize that their view is clearly in line with the "Modernization theory" developed by Lipset (1960). This approach suggests that economic growth and the processes that go along with it, such as expanding education, urbanization, or the development of a middle class, determine institutional change, and not the other way around. Lipset's hypothesis received substantial empirical support from Barro (1999) and Przeworski et al. (2000), and it was recently redeveloped by Friedman (2005).

2.4 Contingency, accidents, and conjuncture hypothesis

The California School of Economic History[15] designates scholars who do not see the Great Divergence as the culmination of a long process of dynamic West vs. stagnant East caused by deep-rooted factors of a biogeographical, cultural, or institutional nature. Rather, members of the California School see the early Western European (and first of all British) take-off as the result of different accidental events that worked in conjunction from the sixteenth to the eighteenth centuries, namely: (i) the difference between divided European nation-states and the unified Chinese empire; the relative sizes of the Atlantic and Pacific oceans, the consequent occurrence of the Atlantic Trade and its impact on pre-modern Western European economies; (iii) the crucial role of coal and its uneven global distribution. Of course, the diverse proponents of this approach do not always agree with each other in every respect, but it is fair to put them under a common heading called the contingency-accidents-conjuncture hypothesis, or more simply the CAC hypothesis.

2.4.1 Relativizing "the West and the Rest"

The first achievement of the California School has been to relativize the alleged singularity of early modern European societies and to rehabilitate the place of Japan and mostly China (in particular its most proto-industrialized regions of the Yellow River and Yangtze River' deltas) in the early modern economy. Wong (1997, p.278) asserts that "China and Europe shared remarkable similarities of preindustrial economic expansion based on Smithian dynamics. These included increased rural industries, more productive agricultures, and expanded commercial networks". In the same way, Pomeranz (2000) suggests that circa 1750, Britain, Eastern China, and Japan had much more similarities than differences regarding capital accumulation, economic institutions (such as security of property), scale and nature of luxury demand, and even material standards of living. Pomeranz is particularly explicit regarding the supposed adequacy of European economic institutions with the onset of industrial

[15] The term was coined by Goldstone (2009) because most of the members of this approach (including Goldstone himself) worked at universities in California.

capitalism. For him "when it came to matters of 'free labor' and markets in the overall economy, Europe did not stand out from China and Japan; indeed, it may have lagged behind at least China. At the very least, all three of these societies resembled each other in these matters far more than any of them resembled India, the Ottoman Empire, or Southeast Asia" (*Ibid.*, p.165). If Lee & Feng (1999), Goldstone (2009), Morris (2010), Parthasarathi (2011), and Vries (2010; 2015) are close to these views, other scholars such as Flynn & Giráldez (1997), Frank (1998), Marks (2002), Goody (2004), Hobson (2004), and Perdue (2005) are more radical and go further in asserting the backwardness of Europe and the primordial role that China played in the world economy to enable the Western European take-off. These authors argue that Western Europe "did not do anything – let alone 'modernize' – by [itself]" (Frank 1998, p.259) since it was "a peripheral, marginal player trying desperately to gain access to the sources of wealth generated in the East" (Marks 2002, p.43).

The main argument of the radical wing of the California School rests on the reality of the huge surplus of silver that flowed from the European colonies of Latin America to China in exchange for silk, ceramics, gold, copper cash, and tea exports towards Western Europe. Scholars do not agree on the magnitude of this silver flow and its beneficial effects for Western Europe. Some of them (Flynn & Giráldez, Frank, Marks, Goody, Hobson, and Perdue) see in this phenomenon a clear demonstration of the economic hegemony of China, whereas for others (Wong, Lee & Feng, Pomeranz, Goldstone, Morris and Vries), it simply corresponds to the monetization of the Chinese economy and it rather translated in a financial windfall for Western Europe. Hence, if for Frank (1998, p.128) "China was only able to satisfy its insatiable 'demand' for silver because it had an inexhaustible supply of exports, which were in perpetual demand elsewhere in the world economy"; for Pomeranz (2000, p.4) "the remonetization of China with silver from the fifteenth century on played a crucial part in making Spain's far-flung New World empire financially sustainable".

2.4.2 Divided European nation-states vs. unified Chinese empire

If most scholars of the California School support that "the West and the Rest" (to take Ferguson (2011)'s words) were far more similar than what Eurocentric authors used to think, they nonetheless recognize that substantial differences existed regarding political structures. As argued by Wong (1997) and Pomeranz (2000, p.194), from the fourteenth to the eighteenth centuries, Europe had violent competing states (Britain, Spain, Portugal, Germany, France, the Netherland, Scandinavia, and Prussia) that were consequently more aggressive in their tactics of trade. On the contrary, China was a unified agrarian empire where elites had few institutionalized claims on the state and hence developed policies and institutions that maintained the existing social order. For Hoffman (2015), incessant warfare among closed nation-states is not sufficient to explain the astonishingly rapid growth in Europe's military sector from the Middle Ages, and its consequences. According to this author, Western Europeans rulers also had lower political costs of summoning resources (through taxes), higher incentives to not use older military technologies, and few obstacles to adopting military innovations. Hence, for Hoffman, it is political history that explains that Western Europe acquired an insurmountable lead in gunpowder technology, which then determined which states established colonial empires or ran the slave trade, and even which economies were the first to industrialize.

2.4.3 Relative ocean sizes and the Atlantic trade

In addition to these political differences, Morris (2010, p.499) highlights that Europe was lucky to have a decisive geographic advantage in reaching the New World since crossing the Atlantic was far more manageable than overcoming the enormous Pacific barrier, hence "more by accident than design, western Europeans created new kinds of oceanic empires." As similarly put by Pomeranz (2000, p.185), "the political-economic institutions of European capitalism and violent interstate competition, combined with some very lucky (for Europe) global conjunctures, made European (especially British) relations

with the rest of the Atlantic world unique among core-periphery relationships." And indeed, as emphasized by all proponents of the CAC hypothesis, the Atlantic Trade allowed the extraction of natural resources (sugar, tea, tobacco, coffee, fur, and more specifically guano, wood, and cotton) from the New World with the extensive use of slaves, and hence flooded Western European markets with new exotic products. Expanding European markets have been greatly beneficial to Western Europe and conducive to an *Industrious* Revolution (i.e., households-size handicraft manufacturing) in many of its constitutive states (de Vries 1994). In such Western European proto-industrial nations, and in particular in Britain, wages broadly increased from the sixteenth to the eighteenth centuries, and hence incentives for labor-saving technologies were important there while inexistent in China, Japan or India where labor remained relatively cheap. Simultaneously, because proto-industry relied heavily on wood fuel, critical levels of wood scarcity, visible both in quantity shortages and price increases, were recurrent in most of Western Europe, and especially in Britain (Pomeranz 2000, pp.220–223).

2.4.3. Crucial role of coal

At these times of consequent incentives for both labor-saving and woodfuel-saving technologies in Western Europe, a fortuitous accident is emphasized by most (if not all) proponents of the CAC hypothesis. This natural accident consists in the lucky endowment of Western European countries, and here again most notably Britain, with large and relatively accessible deposits of coal. Regarding the crucial importance of this energy resource, the work of Pomeranz (2000, p.166, 217) is essential. He calculates *ghost acreages* needed to feed and heat the British population of the nineteenth century if coal and natural resources from the colonies of the Americas (especially wood and food) had not been available. In making such calculations, he explains that without the enormous consumption of coal to replace wood fuel, and the timber and calories imports of the New World, Britain and other countries of Europe would have faced an ecological bottleneck that would have closed the industrial window and probably led Britain towards a Malthusian trap. As comprehensively argued by Allen (2009, 2011) relative factors prices of labor, wood, and coal have surely played a major role in fostering and orienting sustained technological change during the Industrial Revolution. For this author, the British origin of sustained economic growth is due to its favorable coal endowment and the willingness of its people to tap this energy stock thanks to financial incentives represented in relative prices and their ability to applied knowledge brought by science.

In the same line of thought, Kander et al. (2014) assert that the role of coal has been particularly crucial for the Industrial Revolution not as a source of heat, but rather for its high complementary with the steam engine and iron industries to deliver unprecedented amounts of power that vastly reshaped industrializing societies. Similarly, Wrigley (2013, p.10) emphasizes that "a necessary condition for the move from a world where growth was at best asymptotic to one in that it could be, at least for a period, exponential was dependent upon the discovery and exploitation of a vast reservoir of energy that had remained untapped in organic economies. Only by adding the products of plant photosynthesis accumulated over a geological age to the annual cycle of photosynthesis, which had previously been the source of almost all the energy available to human use, could the energy barrier that had constrained growth so severely in the past be overcome".

2.4.4 Increasing probability in a contingent world

This section showed that deep-rooted factors are effective in a certain context so that their long-lasting effect does not imply an absolute once-and-for-all determinism. Hence, the initial advantage given to Western Europe by its natural endowment (cf. Section 2.1) started to loosen circa 1500, but it was then reinforced by cultural traits and institutions supporting the elaboration of modern science in this part of the world (cf. Section 2.2 and 2.3). From then on, successive contingent (China's need for silver) or accidental (Atlantic vs. Pacific sizes, coal deposits endowment) circumstances arose in a

globally favorable conjuncture (rise of nation-states through warfare and early proto-industrialization) to further accentuate the Western European position (cf. Section 2.4). Hence, "the rise of the West and relative backwardness of the East" has surely never been an inevitable outcome, but as time elapsed, such world organization became increasingly probable. Past and ongoing debates reviewed in this section have allowed moving forward with the vertiginous puzzle of the occurrence of the Great Divergence. In particular, it appears that the biogeography, culture, institutions, and contingency/conjuncture hypotheses are not contradictory. Rather, they all had a relatively higher importance at a given moment, but none of these factors uniquely determined the course of the Great Divergence.

Furthermore, despite an understandable widespread desire to see a convergence in wealth among citizens of the different regions of the world, it must be admitted that it is rather a persistence of the Great Divergence that has been witnessed during the last two hundred years. Figure 3 shows that during the twentieth century, all regions of the world had growth rates higher than the leading "Western Offshoots," indicating a process of economic convergence. However, in the last quarter of the twenty century, this process stopped, except for Eastern Asia. Some deep-rooted factors can partially explain the incapacity of certain countries to have fully benefited from modern economic development. However, to explain more precisely the persistence of the Great Divergence up to nowadays, these factors provide an insufficient explanation. Accordingly, the contribution of economic models focusing on proximate causes of growth were also reviewed in the present article. The impact of physical capital and human capital accumulation, technological change, and their underlying causes are crucial to explain this fact. Accordingly, the contribution of economic models focusing on such proximate causes of growth are reviewed in the following section.

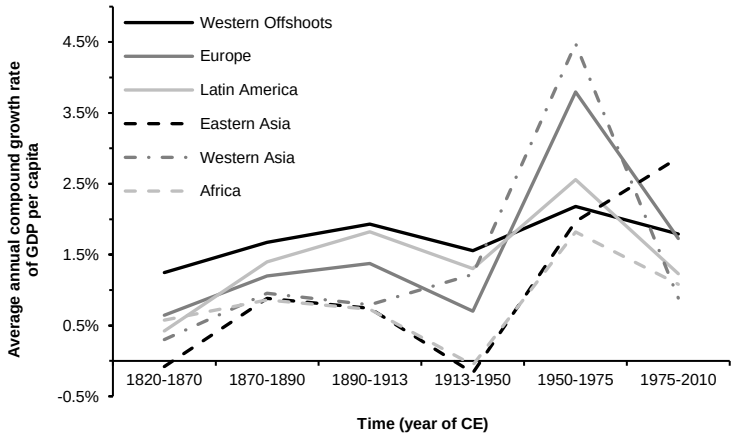

Figure 3. Average annual compound growth rates of world regions, 1820–2010 CE. Data source: The Maddison Project (2013).

3. Proximate causes of economic growth: the contribution of modeling

This section reviews the proximate causes of growth (labor, physical and human capital accumulation, technological progress and its diffusion, international trade) that economists study through theoretical and econometric models. To ease the reading, Table 2 summarizes all proximate causes of growth discussed in the present section.

Table 2. Factors studied as proximate causes of growth in Section 3.

Factors studied as proximate causes of growth	Most important associated references
Physical capital accumulation and technological change	
Saving rate and marginal product of capital	Harrod (1939), Domar (1946)
Saving rate and capital combination with labor	Swan (1956), Solow (1956)
Exogenous technological change	Solow (1957), Barro & Sala-i-Martin (2004), Jorgenson (1995)
Human capital and knowledge spillovers	
Educational level	Barro (1991), Mankiw et al. (1992), Barro & Sala-I-Martin (1992)
Physical spillovers on technological change	Romer (1986)
Human spillovers on technological change	Lucas (1988)
Expanding input variety and Schumpeterian innovation	
Technological change by expanding input variety	Romer (1987, 1990),
Technological change by Schumpeterian innovation	Grossman & Helpman (1991), Aghion & Howitt (1992)
Technological diffusion and international trade	
Human capital to cope with the technology frontier	Acemoglu (2009, pp.613–618)
Institutional barriers to technological diffusion	Parente & Prescott (1994), Howitt (2000), Acemoglu et al. (2007)
Technology frontier vs. countries' needs	Basu & Weil (1998), Acemoglu & Zilibotti (2001)
International trade of financial capital	Lucas (1990), Obstfeld & Taylor (2003), Matsuyama (2004)
International trade of commodities	Ohlin (1967), Ventura (1997), Frankel & Romer (1999)

3.1 Physical capital accumulation and exogenous technological change

3.1.1 Saving rate and marginal product of capital: the Harrod-Domar model

The independent works of Harrod (1939) and Domar (1946) resulted in the so-called Harrod-Domar model, now considered as the first economic growth model. In this model, economic growth arises from an exogenous increase in the savings rate or the marginal product of capital, or from an exogenous decrease in the capital depreciation rate. The main implication is that policies favoring a high saving rate lead to more investment, which fosters capital accumulation and hence generates economic growth. Another conclusion of the Harrod-Domar model is that an economy does not naturally achieve full employment and stable growth rates. The Harrod-Domar model was extensively used to support economic development policies in the 1950s, with the implication that developing countries should borrow to finance investment in capital to trigger economic growth (with the unfortunate consequence of repayment problems). The Harrod-Domar model contains two features that finally led to its abandonment: (i) the saving rate is an exogenous parameter, (ii) there is no explicit aggregated production function since the output is linearly correlated to the capital stock through the constant output-capital ratio.

3.1.2 Saving rate and the combination of capital with labor: the Solow-Swan model

Solow (1956) and Swan (1956) independently worked out the second point to give the renowned Solow-Swan model in which the introduction of an aggregated production function $Y = F(K, L)$ allows

the inclusion of labor as an additional factor of production.[16] The basic Solow-Swan model without technological change has a unique steady state with global asymptotic stability, which depends on exogenous parameters, namely the saving rate, the population growth rate, and the depreciation rate of the capital stock. This model has no sustained growth, meaning that in the absence of technological change and starting with a sufficiently low capital-labor ratio, the basic Solow-Swan model can only generate (ever decreasing) economic growth along its transition path to the steady state, but at this stable point there is no more growth in the capital-labor ratio hence no more capital deepening (i.e., capital intensification), and no more growth in output per capita.[17] An important empirical consequence is that, in such a basic form of the Solow model, capital and labor accumulation explain only a minor part of the whole macroeconomic output growth.

3.1.3 Exogenous technological change and its crucial role

This gap between actual GDP and reconstructed GDP from a production function aggregating physical capital and labor has been called the Solow residual. Early observations showed that this unexplained part of economic growth was increasing over time. Hence this "measure of our ignorance" as put by Abramovitz (1956, p.11) has been attributed to technological change, i.e., change in the productivity with which inputs units of labor and physical capital are used to produce an output unit. Accordingly, if the aggregate production function is to match the historical GDP pattern more closely, a time-dependent multiplier, generally noted A, must be added to take into account the technological progress of the economy (see Figure 3).

In that sense, technological change has a very catch-all definition since very different production-augmenting factors are grossly aggregated in this single variable. Those include: efficiency gains in energy use if this input is considered as a factor of production, but mostly the division and organization of labor, the broader organization and efficiency of other markets, the skill improvements of laborers, the contribution of information and communication technologies, but also the beneficial effects of inclusive institutions (which, for example, protect private property rights and consequently incentivize innovation and R&D). If technology improves the efficiency with which both capital and labor inputs are used, the technology is said to be Hicks-neutral, and the time-dependent multiplier A is correspondingly called Total Factor Productivity (TFP).[18]

As already suggested and visible in Figure 3, technological change seems to explain the largest part of the economic growth process in such version of the Solow-Swan model. But contrary to what one might think, it is hard to be more precise than that because the literature on growth estimates is vast and different approaches such as TFP accounting by means of non-frontier or frontier models, cross-country regressions, and national calibrations are used and debated (Solow, 1957; Barro 1991; Barro & Sala-I-Martin 1992; 2004; Jorgenson et al. 1987; Jorgenson 1995). At the risk of oversimplification, the following order of magnitude can be noted: for a 1% output growth in the Solow-Swan framework, the relative contributions of labor, capital, and technology accumulation are respectively 10–15%, 10–25%,

[16] In Solow (1956), the production function had no particular form but in his following work, Solow (1957) used the famous Cobb-Douglas representation discussed later on in this section. In this particular formulation $Y = K^{\alpha}L^{1-\alpha}$, where α is the constant output elasticity of capital. Recall that the output elasticity of any production factor X is the percentage change in output Y per one percent change in input factor X, all other production factors remaining constant.

[17] The AK model is a special case of the Solow model in which the production function is ultimately linear in the capital stock and can thus display sustained economic growth. However, such setting implies that the share of national income accruing to capital ultimately increases towards 1 (if it is not equal to 1 to start with), which goes against empirical evidences since the capital share in national income is generally around 0.3 for developed countries.

[18] Alternatively, one can only consider purely capital-augmenting (i.e., Solow-neutral) technological change or purely labor-augmenting (i.e., Harrod-neutral) technological change. This last option is often preferred by economists because the first theorem of Uzawa (1961) states that technological change must be asymptotically Harrod-neutral for balanced growth to be possible (i.e., in order to have a constant rate of growth for per capita output, and constant interest rates, capital-output ratio, and national income shares for production factors).

and 60–80%, which basically mean that in a long-term perspective TFP match an exponential function with a 1.5–2% annual growth rate.

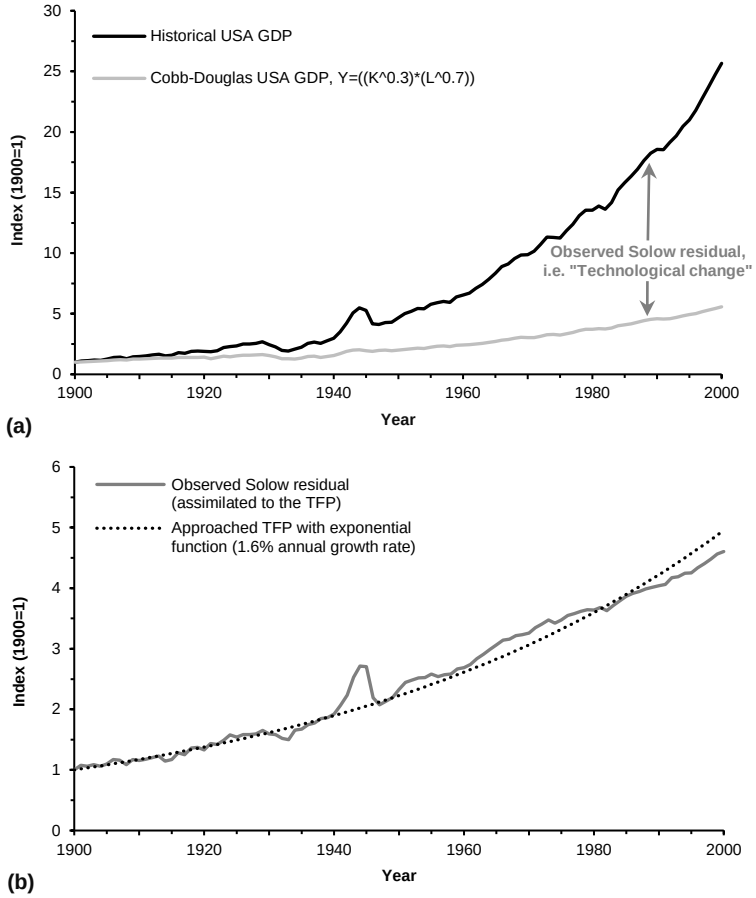

Figure 4. US GDP and Total Factor Productivity (TFP), 1900–2000.
(a) Historical US GDP vs. reproduced US GDP with historical capital and labor aggregated in a Cobb-Douglas function.
(b) Observed vs. approached (with exponential function) Solow residual. Data source: Warr et al. (2010).

The main problem is of course that in such a framework, the technological change that accounts for the lion's share of economic growth is entirely exogenous, and factors that induce some firms and societies to innovate and adopt better technologies remain to be elucidated (models dealing with such issues are reviewed in Section 3.3 and 3.4). Regarding capital accumulation, the Solow-Swan model delivers the idea that countries with higher saving rates, a lower depreciation rate, and lower population growth will have higher capital-labor ratios and hence will be richer. However, here again, those features are determined by purely exogenous parameters.

3.1.4 An improvement with the Ramsey-Cass-Koopmans model

Rediscovering Ramsey (1928) and following the work of von Neumann (1945), Cass (1965) and Koopmans (1965) explicitly modeled the intertemporal utility optimization of a representative household in the economy. Such enhancement led to an endogenization of the saving rate of the representative household within a neoclassical economic growth setting, a framework also called the Ramsey-Cass-Koopmans model, or sometimes more simply the neoclassical growth model. The interesting thing about this model is that the discount rate affects the rate of capital accumulation. A lower discount rate implies greater patience, thus greater savings and hence greater capital accumulation and economic growth. As in the Solow-Swan model, technological progress is indispensable to have sustained economic growth in the Ramsey-Cass-Koopmans model. Moreover, here again, balanced

growth is only possible if technological change is asymptotically purely labor-augmenting (i.e., Harrod-neutral), and if furthermore, the elasticity of intertemporal substitution (which determines the speed of adjustment to the steady-state) tends towards a constant. Accordingly, the Ramsey-Cass-Koopmans model does not provide new insight into the causes of economic growth but only clarifies the nature of economic decisions.

3.2 Human capital and knowledge spillovers

Before turning to the first class of endogenous growth models, we must discuss the inclusion of human capital and its inclusion in exogenous growth frameworks.

3.2.1 Human capital as "educational level" in exogenous growth models

The notion of human capital, generally noted H, was elaborated in the seminal work of Becker (1965) and Mincer (1974). In this conventional view,[19] human capital represents the stock of skills, education, competencies, and other productivity-enhancing characteristics embedded in labor. In other words it represents the efficiency units of labor. Mankiw et al. (1992) were the first to provide a Solow-Swan model augmented with human capital (and purely labor-augmenting technological change). From a theoretical point of view this model has the same comparative statics as the original Solow-Swan model, so it still needs increasing technological progress to display sustained economic growth. However, when performing cross-country regression analyses, Mankiw et al. (1992) found that differences in factors endowments (human and physical capital, and routine labor) explains 78% of the observed differences in GDP level across countries, thus considerably lowering the relative role of technological change compared to previous estimates. The methodology employed by Mankiw et al. (1992) was criticized by Hall & Jones (1999) who proposed an updated value of around 60%.

3.2.2 Other aspects of human capital

If human capital can easily be incorporated into the Ramsey-Cass-Koopmans model or the AK model (see Acemoglu 2009, p.367 and 393 respectively), other aspects of human capital are worth mentioning. First, if the literature on schooling typically finds that one more year of schooling increases earnings by about 6–10%,[20] the Ben-Porath model (1967) shows that there is also on-the-job human capital accumulation after school years. This model also suggests that in countries with high schooling investments, one can also expect higher levels of on-the-job investments in human capital, which would tend to prove that there is a systematic mismeasurement of the amount or quality of human capital across societies as it usually rests on years of schooling. Second, empirical evidence, notably from Krusell et al. (2000), suggests that physical and human capital are complementary so that productivity can be lower than its best potential in case of imperfect labor markets in which factor prices do not necessarily reflect marginal products.

Third, human capital can also have technological externalities as first emphasized by Lucas (1988). Such technological externalities must be understood as the local consequences of human capital concentration which can affect competitive markets and prices. Fourth, according to Schultz (1964) and Nelson & Phelps (1966), the major role of human capital might not be to increase productivity in existing tasks but to enable workers to cope with change, disruptions, and the implementation of new technologies. This "Nelson-Phelps-Schultz" conception of human capital is hence very different from the more conventional "Becker-Mincer" definition of human capital already given.

[19] This term is used to make a distinction between the traditional "Becker-Mincer" approach to human capital and the complementary "Nelson-Phelps-Schultz" perspective described later on in this section.
[20] This is the general agreement found for example by Card (1999), but Duflo (2004) and Ciccone & Peri (2006) found much more lower external returns to schooling around 1–2%.

3.2.3 A brief digression on conditional convergence

The work of Barro (1991) and Barro & Sala-i-Martin (1992; 2004) was instrumental in specifying the notion of convergence among countries and regions since the Great Divergence. These authors found no convergence among countries of the entire world, which is in line with the introduction of the present paper but contradicts the Slow-Swan and Ramsey-Cass-Koopmans models because countries with initially lower capital-labor ratios should have had higher growth rates and converged towards initially richer countries. However, when focusing on clusters of countries which have much more similar levels of education, institutions, policies, and initial conditions, Barro (1991) and Barro & Sala-i-Martin (1992; 2004) have shown that it is possible to find some conditional convergence, meaning convergence after controlling for measures of education and government policies. Hence, in these studies, it is found that the income gap between countries that have the same human capital endowment has been narrowing over the postwar period on average at about two percent per year. In the same way, these authors show that after controlling for measures of education and government policies, developing countries tend to grow faster than rich one.

As explained by Jones (1997), another significant finding of this literature is that one can interpret the variation in growth rates around the world as reflecting how far countries are from their steady-state positions. For example, Korea and Japan grew rapidly in the 1980s–1990s because their steady-state positions in the income distribution were much higher than their actual positions. Venezuela grew slowly other the same period because the reverse was true.

At this point, the modern growth process is still obscure because the dynamics of the proximate causes of growth (physical and human capital accumulation, and technological change) are determined by exogenous parameters (population growth rate, depreciation rate, technological growth rate, saving rate, or discount rate and elasticity of intertemporal substitution in Ramsey-like settings). Hence, we must review the contribution of the endogenous growth literature of the 1990s.

3.2.4 First models of quasi-endogenous growth: knowledge spillovers from capital

The first model of quasi-endogenous economic growth came from Romer (1986) who regards knowledge accumulation as a byproduct of physical capital accumulation. In this model, the production function aggregates purely physical capital with routine labor and the technology is exclusively labor-augmenting. The key concept is then to consider that although firms take the technological level A as given, this stock of knowledge is a linear function of the physical capital stock K. In this sense, technology is the result of spillovers from physical capital and it evolves endogenously for the economy as a whole. This assumption appeals to the concept of learning-by-doing, whereby greater investment in a given sector increases the experience of workers and managers in the productive process and hence makes the production process itself more productive (Arrow 1962). A very important point to notice is that the linear relation between technology and physical capital developed by Romer (1986) implies increasing returns to scale in the overall production process, whereas the different models presented so far have constant returns to scale. While arguably crude, Romer (1986)'s formalization also captures the idea that knowledge is a nonrival good, meaning that once a particular technology has been discovered, many firms can make use of this technology without precluding its use by others.[21]

Another important paper came from Lucas (1988) who constructed a model with a similar structure except that technology evolves as a linear function of human and not physical capital (i.e.,

[21] On the contrary knowledge can be an excludable good if patent rights and copyrights are implemented to protect the results of research and development.

Romer has physical capital externalities, whereas Lucas has human capital externalities).[22] In the different models presented so far, sustained economic growth is either the result of exogenous technological change or a by-product of knowledge spillovers from exogenous physical or human capital accumulation. The following subsection investigates models in which economic growth results from technological progress itself as a consequence of purposeful investments by firms and individuals.

3.3 Expanding variety, Schumpeterian innovation, and directed technological change

3.3.1 Endogenous technological change by expanding input variety

Inspired by the Dixit-Stiglitz (1977) model of industry equilibrium, Romer (1987) was the first to provide an economic growth model based on expanding input varieties. In this kind of model (also called the lab-equipment model of growth), different intermediate machine-inputs are aggregated with labor in the sector producing the final good, and the economic growth potential is a function of the number N of these different intermediate machine-input goods. Furthermore, the number of machines developed by the intermediate sector depends on the level of expenditure in research and development (R&D). With free entry for firms into the R&D sector, greater spending is rewarded with a perpetual monopolistic position on the blueprint or idea that is invented to produce the machine, which leads to the increasing invention of new machines (hence the name "expanding variety" model) and consequently to an increase in the final output good and therefore to economic growth.

In another paper, Romer (1990) separates the rival component of knowledge, i.e., human capital H, from the nonrival component, i.e., the number of designs or machines A. In doing so he introduces knowledge spillovers from human capital H toward the technological component A, a phenomenon also known as the "standing on giant's shoulders effect". Basically, contrary to Romer (1987) where R&D is fueled by scarce physical capital expenditure, in Romer (1990) R&D is a function of the potentially infinite human capital. This specification led Romer (1990, p.99) to conclude about his model that its most interesting positive implication "is that an economy with a larger total stock of human capital will experience faster growth", and "that low levels of human capital may help explain why growth is not observed in underdeveloped economies that are closed and why a less developed economy with a very large population can still benefit from economic integration with the rest of the world". Regarding the persistence of the Great Divergence, the opinion of Romer is straightforward when he asserts that his analysis "offers one possible way to explain the wide variation in growth rates observed among countries and the fact that in some countries growth in income per capita has been close to zero".

3.3.2 Endogenous technological change by Schumpeterian innovation

It is important to note that models of expanding machine variety may not provide a good description of innovation dynamics in practice because they do not capture its qualitative aspect. Indeed, in addition to the increasing number of product lines (i.e., horizontal innovation), Schumpeter (1942) theorized the concept of creative destruction by which economic growth is mainly driven by the innovation of new machines and products replacing old ones (i.e., vertical innovation), and hence possibly new firms replacing incumbents. That is why models discussed in the "quality ladder realm" are also called "Schumpeterian growth" models. Segerstrom et al. (1990) developed the first model of

[22] A third important model of the bourgeoning endogenous growth literature of the early 1990s is the two-sector AK model of Rebelo (1991). In this model the consumption good uses capital and labor in a Cobb-Douglas function with a Hicks-neutral technology, while the investment good only consumes capital as an input. This formulation has the advantage of presenting sustained economic growth with constant factor shares in national income, contrary to the original one-sector AK model in which the capital income share is ultimately equal to unity.

this paradigm, but the versions of Grossman & Helpman (1991) and Aghion & Howitt (1992) are more renowned.[23]

In contrast to expanding variety models in which economic growth is determined by the increasing number of machines (or blueprints/designs), in Schumpeterian models, the engine of growth is the process of innovations leading to the increasing quality improvements of a fixed number of machines. Formally, the idea is to think that there is a quality ladder for each machine variety, and each innovation takes the machine quality up by one rung on this ladder (Acemoglu 2009, p.459). A crucial assumption is that the different qualities of the same machine are perfect substitutes and that in equilibrium only the leading-edge (i.e., highest quality) version of each machine type is used. This aspect is at the center of the process of creative destruction because when a higher quality machine is invented the previous vintage of the same machine becomes useless and is consequently destroyed.[24] In such models, it is shown that there is no transitional dynamics and there exists a unique balanced growth path in which the average quality of machines, output, and consumption grow at the same rate.[25]

3.3.3 Some criticisms and the direction of technological change

Three important points must be mentioned about the different endogenous models previously reviewed. First, these models (except Romer 1990) include a population scale effect so that a higher population leads to a higher growth rate. A practical and paradoxical implication is that population must be held constant for these models to admit the balanced growth path supposedly representative of modern economies.

Second, while exogenous models have difficulties in generating substantial income differences across countries, endogenous models suffer from the opposite problem. Indeed, with Solow-Swan and Ramsey-Cass-Koopmans settings, even quite large differences in cross-country distortions (e.g., manifold differences in effective tax rates) do not generate significant income per capita differences in the steady-state, which contradicts the reality of the Great Divergence (as shown in Figure 1). On the other hand, with expanding input variety and Schumpeterian models, even small differences in policies, technological opportunities, or other characteristics of societies, lead to permanent differences in long-run growth rates. This outcome means that these models are better equipped to explain the persistence of the Great Divergence, but at the same time, they predict an ever-expanding income distribution across countries whereas data suggest a relative stability for the more recent decades (as said in the introduction of the present article).

Third, in all endogenous models previously presented, technological change (by knowledge spillovers, increasing input varieties, or increasing input quality) increases the aggregate productivity of the economy, but in practice, technological change is often directed towards one kind of agents or another. Indeed, historical evidence supports the idea that during the nineteenth-century, technological change was unskilled-biased, but in the early twentieth century this phenomenon was reversed, so that technological change has been increasingly skilled-biased during the last one hundred years in developed countries.[26]

---

[23] Aghion & Howitt (1998) provide an excellent survey of many Schumpeterian models of economic growth and numerous extensions regarding employment, step-by-step vs. cumulative innovations, and so on.

[24] Another very important aspect of Schumpeterian growth models is that only new entrant firms undertake R&D. This is logical because the incumbent has weaker incentives to innovate since it would replace its own machine for which it enjoys the benefit of a perpetual patent.

[25] In Aghion & Howitt (1992) the economy has a constant output for a precise interval of time and experiences a burst of growth when a new machine is invented. Whether this pattern of uneven growth provides a better approximation to reality than the continuous growth of Segerstrom et al. (1990) and Grossman & Helpman (1991) is open to debate.

[26] For the quantitative evidence of these two successive phenomena see: Goldin & Katz (1998) and Mokyr (2011) for the unskilled bias of technological change during the nineteenth and early twentieth century; and Katz & Autor (1999) and Acemoglu (2002b) for the accelerating skilled bias in the twentieth century. Moreover, mathematical models on directed technological change have been developed within expanding input variety or Schumpeterian frameworks, see for example

While the three previous subsections have highlighted how the proximate causes of economic growth have been inserted into mathematical representations, they all consider that each country is a closed economy that does not interact with the rest of the world. In reality, many countries not only generate technological change from their national R&D sector, but they also benefit from the advances in the world technology frontier. Moreover, international trade of financial capital and commodities has an influence on economic growth that will also be analyzed.

3.4 Technology diffusion and international trade

3.4.1 Role of human capital to cope with the world technology frontier

As already stressed, one significant criticism of the Solow-Swan and the Ramsey-Cass-Koopmans models regards their inability to generate quantitatively substantial differences in cross-country income per capita, and many economists relate this to the incapacity of these analytical frameworks to explain technological differences across countries. Acemoglu (2009, pp.613–618) provides an augmented Ramsey-Cass-Koopmans model in which the world economy consists of J countries, indexed by $j \in [1, \dots, J]$, each with access to a technology A_j that is lower than the world technology frontier A encapsulating the maximal knowledge that any country could have. The interesting feature of this model is to consider that each country absorbs the world technology following the exogenous rate σ_j, and also improves its technology thanks to local R&D at the exogenous speed λ_j.

Then, it is assumed that these parameters depend on the specific human capital stocks of each country, with the absorption rate σ_j being linked to the Nelson-Phelps-Schultz approach of human capital, and λ_j corresponding to the more traditional Becker-Mincer view, both defined in Section 3.2. Since in this model σ_j multiplies $(A - A_j)$, an important implication is that countries that are relatively backward, in the sense of having a low A_j compared to the world technology frontier A, tend to grow faster because they have a higher technological gap to resorb (i.e., more room to catch-up). This force, pulling backward economies toward the technology frontier, is powerful enough to ensure that in the steady state all countries grow at the exogenous growth rate of the world technology frontier. Thus, in this model differences in saving rates, absorptions rates σ_j, and the specific technological speed of convergence λ_j, translate into different development levels but similar growth rates across countries.

3.4.2 Institutional barriers preventing technology diffusion

An alternative interpretation of the absorption rates σ_j is to link them to differences in institutional barriers to technology adoption (property rights, taxes, or other policy features). This is the option chosen by Parente & Prescott (1994) who proposed a model of technology diffusion within an expanding input variety setting, whereas Howitt (2000) follow the same approach in a Schumpeterian framework. In such models, investment affects technology absorption and countries differ in terms of the barriers that they place in the path of firms in this process. As in the simpler model of Acemoglu previously studied, all countries grow at the same rate in these models, and differences in the cost of technology adoption determine differences in the level of per capita income across countries.

However, the advantage of these last two models is that the rate of growth of the world technology frontier, and hence of economic growth, is endogenous. These perspectives are interesting but how exactly institutions affect technology is left as a black box. An intuitive answer to such a question is given by Acemoglu et al. (2007). In a Schumpeterian setting, this paper illustrates how contractual difficulties can affect the relationship between producers and suppliers and thus change the

Acemoglu (2002a) and Duranton (2004). Furthermore, the link between directed technological change and international trade is studied by Thoenig & Verdier (2003).

profitability of technology adoption, which leads to differences in technology adoption and productivity patterns across countries.

3.4.3 Inadequacy of the world technology frontier with developing countries' needs

Moreover, in the absence of institutional barriers, it is possible that technological differences and income gaps remain because the world technology frontier is inappropriate to the specific needs of developing countries. If that is the case, importing the most advanced frontier technologies may not guarantee a convergence of the productivity of all countries. Since OECD countries are both the producers of much new know-how and the largest markets for new technologies, it is logical to expect that new technologies are optimized for the conditions and the needs of these countries, and not for developing ones. This point is developed in the context of a Solow-type growth model by Basu & Weil (1998), whereas Acemoglu & Zilibotti (2001) discuss more broadly the implications of the mismatch between technologies developed in advanced economies and the skills of the workforce of developing countries.

3.4.4 International trade of financial capital

When witnessing the remarkable cross-country difference in income per capita that has existed since the initiation of the Great Divergence, one might wonder why this gap has not been narrowed by a flow of financial capital from rich to developing countries. In a globalized economy, if the rates of return on capital differ across countries as a consequence of different capital-labor ratios, we would expect capital to flow towards areas with lower capital-labor ratios where rates of return on capital are higher, i.e., towards poorer countries. As a consequence of such financial flows, capital-labor ratios of countries would equalize, and economies would converge in terms of income per capita. One way to explain the absence of such fact would be to simply remark that the international capital market is surely not frictionless and that additional sovereign risk probably prevents such flows.[27] However, Lucas (1990) shows that even with perfect international capital markets, if the productivities of countries are different, capital flows equalize *effective* capital-labor ratios (i.e., capital-labor ratios times technological levels), but this does not imply the equalization of capital-labor ratios. Hence, in such a model, there is no reason to expect financial capital to flow from rich to developing countries.

3.4.5 International trade of commodities and specialization

Apart from international trade in financial assets, international trade in commodities is perhaps even more important for the economic growth process. Within the neoclassical paradigm, international trade is usually studied through the Heckscher-Ohlin model (1967),[28] which reformulates the idea of comparative advantage first enunciated by Ricardo (1817). In basic and augmented Heckscher-Ohlin models, the world economy has a standard neoclassical production function, whereas each country faces an AK technology. Thus a given country can accumulate as much capital as he wishes without running into diminishing returns (as long as the country remains small, which is always a valid hypothesis in a medium-run perspective). As a consequence, Ventura (1997) proposes that the augmented Heckscher-Ohlin model with conditional factor price equalization can easily rationalize the growth miracles that countries can sometimes display for a few decades. In particular, this mechanism can explain that between the 1960s and 1990s, the East Asian Tigers (Hong Kong, Singapore, South Korea, and Taiwan) accumulated capital more rapidly than many other developing countries thanks to their greater openness

[27] Obstfeld & Taylor (2003) provide a survey of the literature on why capital does not flow from rich to poor countries. Other interesting references on this topic are Kehoe & Perri (2002), and Matsuyama (2004).

[28] The original essay of Ohlin was published in 1933. Although Ohlin wrote the book alone, his doctoral thesis director Heckscher was credited as co-developer of the model which was mathematically formalized in the second edition of 1967.

to international trade. They did so without experiencing diminishing returns and consequently witnessed sustained growth at far higher rates than the world average.

Regarding the question of the impact of trade openness on economic growth more specifically, the theoretical literature is slightly mixed but more for a positive effect. For example, Frankel & Romer (1999) find that international trade in a model of expanding input variety implies that trade encourages technological change and increases the endogenous growth rate of the world economy. On the empirical side, Dollar (1992) and Sachs & Warner (1995) find a positive correlation between openness to international trade and economic growth but such a correlation is of course not similar to cause (see the previous discussion on the difficulty to empirically relate cultural traits and institutional quality to economic growth).

3.4.6 International trade and the stability of the world income distribution

The work of Acemoglu & Ventura (2002) highlights the role of international trade in ensuring a stable world income as witnessed in the persistence of the Great Divergence. In this Ricardian model, all countries have different technologies and consequently specialize in the production of one of the N intermediate inputs. As a consequence, when a country accumulates capital faster than the rest of the world, and thus increases the supply of its exports compared to the supplies of other nations' exports, the price of its export goods declines compared to other countries' goods, and hence it will face worse terms-of-trade. This negative terms-of-trade effect reduces its income and its rate of return on capital, which slows down capital accumulation. As a consequence, the world economy, and in fact all national economies, move toward a unique stable steady-state where all countries grow at the same exogenous rate. In other words, international trade together with terms-of-trade effects leads to a stable world income distribution in this model, a feature of the reality that other international trade models rarely present.[29]

4. Conclusion and perspectives

Over the years, scholars have accumulated a colossal amount of knowledge on the causes of the occurrence and persistence of the Great Divergence. These data, demonstrations, and reflections are now so widespread in thousands of articles and hundreds of books that retaining an accurate "big picture" has become increasingly difficult for researchers, not mentioning the potential feeling of despair that it can generate for novices who wish to start their inquiry of this master enigma. Therefore, the present article contributes to the literature on economic growth by providing a comprehensive review of all deep-rooted and proximate causes of economic growth in a unique document.

Several biogeographical factors (climate conditions, continental sizes, orientation of major continental axes, length of coastline compared to mainland area) have had an undeniable deep-rooted influence on the timing of the Agricultural Revolution of the Neolithic, which then had long-lasting effects on the differential development of world regions. The initial advantage of Eurasia loosened over time, but circa 1500 CE it was more probable to bet on a future take-off from near-stagnation to sustained growth in that part of the world rather than elsewhere.

[29] One might see an inconsistency between the Heckscher-Ohlin model of Ventura (1997) and the Ricardian setting of Acemoglu & Ventura (2002). Indeed, in the latter higher than average capital accumulation cannot last because of the worsening terms-of-trade effect, whereas in the former fast capital accumulation without diminishing returns is able to explain how certain economies can grow rapidly for extended periods. This conflict is resolved if one assumes that an early developing country is specializing and thus can accumulate capital without diminishing returns and no worsening terms of trade, whereas a more advanced economy produces more differentiated goods and is consequently better described by a situation of diminishing returns on capital and a terms-of-trade effect.

Culture (in particular religion) and its social implementation through institutions have then had a critical role in determining the different scientific and technological trajectories of world regions. Despite obvious technological discoveries, the successive Islamic and Chinese empires gradually developed monolithic and relatively rigid societies in contrast to the more pluralistic countries of Europe whose scientists were incentivized to discover the natural laws of the world. Accordingly, the emergence of modern science in the technologically backward Europe of pre-industrial times seem to have been influential in determining the global location of the Industrial Revolution.

At that point, a future economic take-off towards modern growth was far more probable in Western Europe, but it was possible in any part of it. Indeed, as put by Mokyr (2011, p. 486), "ideology was an integral part of economic change, but just as there is no fixed set of 'good' institutions that are suitable for the economy under all circumstances, there is no 'right' ideology that works in all circumstances toward economic progress.". Hence, it is then a succession of historical and contingent events (Atlantic trade, labor-saving incentives, the location of coal deposits, institutional flexibility) that worked in conjunction to explain the earliness of Britain in reaching a modern regime of economic growth.

In summary, deep-rooted factors are effective in a certain context so that their long-lasting effects do not imply an absolute once-and-for-all determinism. Hence, "the rise of the West and relative backwardness of the East" has surely never been an inevitable outcome, but as time elapsed, such world organization became increasingly probable. In particular, it appears that the biogeography, culture, institutions, and contingency/conjuncture hypotheses are not contradictory. Rather, they all had a relatively higher importance at a given moment, but none of these factors uniquely determined the course of the Great Divergence. Furthermore, despite an understandable widespread desire to see a convergence in wealth among citizens of the different regions of the world, it must be admitted that it is rather a persistence of the Great Divergence that has been witnessed during the last two hundred years. Some deep-rooted factors can partially explain the incapacity of certain countries to have fully benefited from modern economic development. However, to explain more precisely the persistence of the Great Divergence up to nowadays, these factors provide an insufficient explanation (Figure 5).

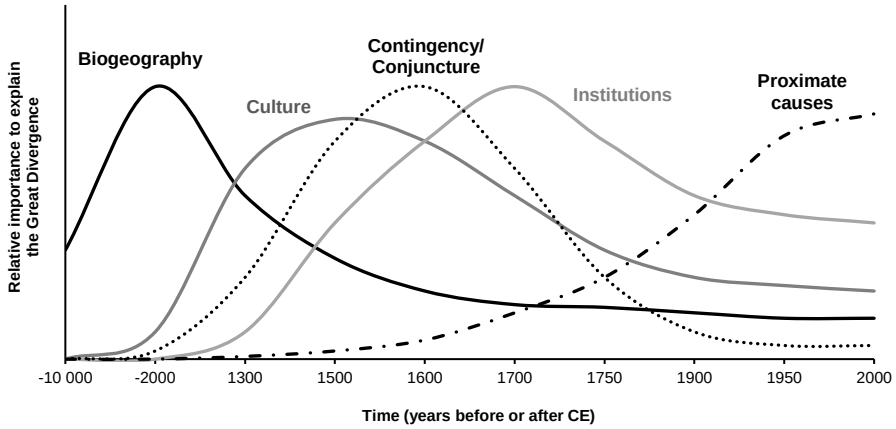

Figure 5. Relative importance over time of deep-rooted and proximate causes of growth to explain the Great Divergence.

Accordingly, the contribution of economic models focusing on proximate causes of growth were also reviewed in the present article. First theoretical models have stressed the importance of savings for investments and capital accumulation to foster economic growth. Such analytical frameworks were labelled "exogenous" because their dynamics were driven by exogenous parameters (population growth rate, depreciation rate, saving rate, or discount rate and elasticity of intertemporal substitution in Ramsey-like settings), and more importantly by an exogenous increasing variable needed to explain

why aggregated output grew much faster than aggregated inputs. In first econometric studies, such mysterious "technological change," as it was baptized, took the lion's share to explain economic growth. The inclusion of a novel factor of production representing the human capital of population helped to narrow the relative importance of technological change. The second generation of models focused on the endogenization of technological change. A first approach was to understand technological change as an increasing production of intermediate inputs (designs, machines) used in final production. A second approach made use of Schumpeter's work and conceptualized technological change as a production of intermediate inputs of increasing quality rather than quantity.

While exogenous models have difficulties in generating substantial income differences across countries, endogenous models suffer from the opposite problem. Indeed, with Solow-Swan and Ramsey-Cass-Koopmans settings, even quite large differences in cross-country distortions (e.g., manifold differences in effective tax rates) do not generate significant income per capita differences in the steady-state, which contradicts the reality of the Great Divergence. On the other hand, with expanding input variety and Schumpeterian models, even small differences in policies, technological opportunities, or other characteristics of societies, lead to permanent differences in long-run growth rates. This outcome means that these models are better equipped to explain the persistence of the Great Divergence, but at the same time, they predict an ever-expanding income distribution across countries whereas data suggest possibilities for convergence, as witnessed during the middle of the twentieth century, and a relative stability for the more recent decades.

In summary, theoretical models and econometric studies have surely enabled some progress to understand the process of modern economic growth. The role of physical and human capital in conjunction with routine labor and technological change is indisputable, but it is the assessment of their intricacies and relative importance over time that is still more debatable. Theoretical and econometric models have also provided useful analytical tools to examine some reasons behind the persistence of the Great Divergence, namely: the role of human capital or institutional barriers to cope with the world technology frontier through technology diffusion, the mismatch between technological needs of developing countries and the world technology frontier, and the impact of international trade of financial assets and commodities.

It is worth noting that mathematical models of economic growth have been almost exclusively designed to enlight the growth process of economies that are already in a modern regime of high sustained growth (i.e., industrialized post-World War II economies). The inconsistency of such models to depict the central driving force leading to a transition from near-stagnation to sustained growth has resulted in a search for a common *Unified Growth Theory* (see Galor 2011) that would unveil the underlying micro-foundations of this most remarkable transformation. The goal of this emerging and progressing theory is to provide a unique analytical framework to study both the occurrence and the persistence of the Great Divergence.

Acknowledgements

The author would like to thank Pierre-Olivier Pineau and Adrien Nguyen-Huu for their helpful comments on earlier versions of this article.

References

Abramovitz, M., 1956. Resource and Output Trends in the U.S. since 1870. *American Economic Review*, 46(2), pp.5–23.

Acemoglu, D., 2002a. Directed Technical Change. *Review of Economic Studies*, 69(4), pp.781–809.

Acemoglu, D., 2002b. Technical Change, Inequality and the Labor Market. *Journal of Economic Literature*, 40(1), pp.7–72.
Acemoglu, D., 2009. *Introduction to Modern Economic Growth*, Princeton, NJ: Princeton University Press.
Acemoglu, D. & Robinson, J.A., 2000. Political Losers as a Barrier to Economic Development. *American Economic Review*, 90(2), pp.126–130.
Acemoglu, D. & Robinson, J.A., 2006. Economic Backwardness in Political Perspective. *American Political Science Review*, 100(1), pp.115–131.
Acemoglu, D. & Robinson, J., 2012. *Why Nations Fail: The Origins of Power, Prosperity, and Poverty*, New York, NY: Crown Publishers.
Acemoglu, D. & Ventura, J., 2002. The World Income Distribution. *Quarterly Journal of Economics*, 117(2), pp.659–694.
Acemoglu, D. & Zilibotti, F., 2001. Productivity Differences. *Quarterly Journal of Economics*, 116(2), pp.563–606.
Acemoglu, D., Antras, P. & Helpman, E., 2007. Contracts and Technology Adoption. *American Economic Review*, 97(3), pp.916–943.
Acemoglu, D., Johnson, S. & Robinson, J.A., 2001. The Colonial Origins of Comparative Development: An Empirical Investigation. *American Economic Review*, 91(5), pp.1369–1401.
Acemoglu, D., Johnson, S. & Robinson, J.A., 2002. Reversal of Fortune: Geography and Institutions in the Making of the Modern World Income Distribution. *Quarterly Journal of Economics*, 117(4), pp.1231–1294.
Aghion, P. & Howitt, P., 1992. A Model of Growth Through Creative Destruction. *Econometrica*, 60(2), pp.323–351.
Aghion, P. & Howitt, P., 1998. *Endogenous Growth Theory*, Cambridge, MA: MIT Press.
Alesina, A. & Rodrik, D., 1994. Distributive Politics and Economic Growth. *Quarterly Journal of Economics*, 109(2), pp.465–490.
Alesina, A. & La Ferrara, E., 2005. Ethnic Diversity and Economic Performance. *Journal of Economic Literature*, 43(3), pp.762–800.
Alesina, A. & Fuchs-Schündeln, N., 2007. The Effect of Communism on People's Preferences. *American Economic Review*, 97(4), pp.1507–1528.
Alesina, A. et al., 2003. Fractionalization. *Journal of Economic Growth*, 8, pp.155–194.
Allen, R.C., 2009. *The British Industrial Revolution in Global Perspective*, Cambridge, UK: Cambridge University Press.
Allen, R.C., 2011. Why the industrial revolution was British: commerce, induced invention, and the scientific revolution. *Economic History Review*, 64(2), pp.357–384.
Alston, L.J., Eggertsson, T. & North, D.C. eds., 1996. *Empirical Studies in Institutional Change*, Cambridge, UK: Cambridge University Press.
Arcand, J.-L., Guillaumont, P. & Guillaumont Jeanneney, S., 2000. How to make a tragedy: on the alleged effect of ethnicity on growth. *Journal of International Development*, 12(7), pp.925–938.
Arrow, K.J., 1962. The Economic Implications of Learning by Doing. *Review of Economic Studies*, 29(3), pp.155–173.
Arruñada, B., 2010. Protestants and Catholics: Similar Work Ethic, Different Social Ethic. *Economic Journal*, 120(547), pp.890–918.
Ashraf, Q. & Galor, O., 2011. Dynamics and Stagnation in the Malthusian Epoch. *American Economic Review*, 101(5), pp.2003–2041.
Ashraf, Q. & Galor, O., 2013. The "Out of Africa" Hypothesis, Human Genetic Diversity, and Comparative Economic Development. *American Economic Review*, 103(1), pp.1–46.
Ashraf, Q. & Galor, O., 2014. Response to Comments made in a Letter by Guedes et al. on "The Out of Africa Hypothesis, Human Genetic Diversity, and Comparative Development." *Open letter available online*.
Ashraf, Q. & Galor, O., 2017. The Macrogenoeconomics of Comparative Development. *NBER Working Paper No. 23199*, pp.1–44.
Barro, R.J., 1999. Determinants of Democracy. *Journal of Political Economy*, 107(S6), pp.S158–S183.
Barro, R.J., 1991. Economic Growth in a Cross Section of Countries. *Quarterly Journal of Economics*, 106(2), pp.407–443.

Barro, R.J. & McCleary, R.M., 2003. Religion and Economic Growth Across Countries. *American Sociological Review*, 68(5), pp.760–781.
Barro, R.J. & Sala-i-Martin, X., 2004. *Economic Growth* 2nd ed., Cambridge, MA: MIT Press.
Barro, R.J. & Sala-I-Martin, X., 1992. Convergence. *Journal of Political Economy*, 100(2), pp.223–251.
Basu, S. & Weil, D.N., 1998. Appropriate Technology and Growth. *Quarterly Journal of Economics*, 113(4), pp.1025–1054.
Becker, G.S., 1965. A Theory of the Allocation of Time. *Economic Journal*, 75, pp.493–517.
Becker, S.O. & Woessmann, L., 2009. Was Weber Wrong? A Human Capital Theory of Protestant Economic History. *Quarterly Journal of Economics*, 124(2), pp.531–596.
Becker, S.O. & Woessmann, L., 2010. The Effect of Protestantism on Education Before the Industrialization: Evidence from 1816 Prussia. *Economics Letters*, 107(2), pp.224–228.
Ben-Porath, Y., 1967. The Production of Human Capital and the Life Cycle of Earnings. *Journal of Political Economy*, 75(1), pp.352–365.
Benabou, R., 2000. Unequal Societies: Income Distribution and the Social Contract. *American Economic Review*, 90(1), pp.96–129.
Benjamin, D.J. et al., 2012. The Promises and Pitfalls of Genoeconomics. *Annual Review of Economics*, 4, pp.627–662.
Bloom, D.E. & Sachs, J.D., 1998. Geography, Demography, and Economic Growth in Africa. *Brookings Papers on Economic Activity*, 2, pp.207–295.
Bourguignon, F. & Morrisson, C., 2002. Inequality Among World Citizens: 1820-1992. *American Economic Review*, 92(4), pp.727–744.
Braudel, F., 1996. *The Mediterranean and the Mediterranean World in the Age of Philip II*, Oakland, CA: University of California Press.
de Candolle, A., 1885. *Histoire des Sciences et des Savants Depuis Deux Siècles*, Genève-Bale: H. Georg.
Cantoni, D., 2015. The Economic Effects of the Protestant Reformation: Testing the Weber Hypothesis in the German Lands. *Journal of the European Economic Association*, 13(4), pp.561–598.
Card, D., 1999. The Causal Effect of Education on Earnings. In O. Ashenfelter & D. Card, eds. *Handbook of Labor Economics, Vol. 3A*. Amsterdam, NL: Elsevier B.V., p. 1801–1863.
Cass, D., 1965. Optimum Growth in an Aggregative Model of Capital Accumulation. *Review of Economic Studies*, 32(3), pp.233–240.
Ciccone, A. & Peri, G., 2006. Identifying Human-Capital Externalities: Theory with Applications. *Review of Economic Studies*, 73(2), pp.381–412.
Clark, G., 2007. *A Farewell to Alms: A Brief Economic History of the World*, Princeton, NJ: Princeton University Press.
Clark, G., 2008. In defense of the Malthusian interpretation of history. *European Review of Economic History*, 12(2), pp.175–199.
Collier, P., 2000. Ethnicity, Politics and Economic Performance. *Economics & Politics*, 12(3), pp.225–245.
Collins, J., Baer, B. & Weber, E.J., 2016. Evolutionary Biology in Economics: A Review. *Economic Record*, 92(297), pp.291–312.
Crosby, A.W., 1986. *Ecological Imperialism: The Biological Expansion of Europe, 900-1900*, Cambridge, UK: Cambridge University Press.
Diamond, J.M., 1997. *Guns, Germs, and Steel: The Fates of Human Societies*, New York, NY: W.W. Norton & Company.
Dixit, A.K. & Stiglitz, J.E., 1977. Monopolistic Competition and Optimum Product Diversity. *American Economic Review*, 67(3), pp.297–308.
Dollar, D., 1992. Outward-Oriented Developing Economies Really Do Grow More Rapidly: Evidence from 95 LDCs. *Economic Development and Cultural Change*, 40(3), pp.523–544.
Domar, E.D., 1946. Capital Expansion, Rate of Growth, and Employment. *Econometrica*, 14(2), pp.137–147.
Duflo, E., 2004. The Medium Run Effects of Educational Expansion: Evidence From a Large School Construction Program in Indonesia. *Journal of Development Economics*, 74, pp.163–197.
Duranton, G., 2004. The Economics of Production Systems: Segmentation and Skill-Biased Change. *European Economic Review*, 48, pp.307–336.

Easterly, W. & Levine, R., 1997. Africa's Growth Tragedy: Policies and Ethnic Divisions. *Quarterly Journal of Economics*, 112(4), pp.1203–1250.
Easterly, W. & Levine, R., 2003. Tropics, germs, and crops: How endowments influence economic development. *Journal of Monetary Economics*, 50(1), pp.3–39.
Ferguson, N., 2011. Civilization: the West and the Rest, New York, NY: Penguin Press.
Flynn, D.O. & Giráldez, A. eds., 1997. *Metals and Monies in an Emerging Global Economy*, Brookfield, VT: Variorum.
Frank, A.G., 1998. *ReOrient: Global Economy in the Asian Age*, Berkeley, CA: University of California Press.
Frankel, J.A. & Romer, D., 1999. Does Trade Cause Growth? *American Economic Review*, 89(3), pp.379–399.
Friedman, B.M., 2005. *The Moral Consequences of Economic Growth*, New York, NY: Penguin Random House.
Gallup, J.L., Sachs, J.D. & Mellinger, A., 1999. Geography and Economic Development. *International Regional Science Review*, 22(2), pp.179–232.
Galor, O., 2011. *Unified Growth Theory*, Princeton, NJ: Princeton University Press.
Gambetta, D., 1988. Can We Trust Trust? In D. Gambetta, ed. *Trust : Making and Breaking Cooperative Relations*. New York, NY: Blackwell Publishers Ltd.
Glaeser, E.L., Porta, R. La & Shleifer, A., 2004. Do Institutions Cause Growth? *Journal of Economic Growth*, 9, pp.271–303.
Goldin, C. & Katz, L. F.,1998. The Origins of Technology-Skill Complementarity. *Quarterly Journal of Economics*, 113(3), pp.693–732.
Goldstone, J.A., 2009. *Why Europe? The Rise of the West in World History, 1500-1850*, Boston, MA: McGraw-Hill Higher Education.
Goody, J., 2004. *Capitalism and Modernity: The Great Debate*, Cambridge, MA: Polity.
Grantham, G., 2008. Explaining the industrial transition: a non-Malthusian perspective. *European Review of Economic History*, 12(2), pp.155–165.
Grayson, D.K., 1991. Late Pleistocene Mammalian Extinctions in North America: Taxonomy, Chronology, and Explanations. *Journal of World Prehistory*, 5(3), pp.193–231.
Greif, A., 1994. Cultural Beliefs and Organization of Society: A Historical and Theoretical Reflection on Collectivist and Individualist Societies. *Journal of Political Economy*, 102(5), pp.912–950.
Greif, A., 2006. *Institutions and the Path to the Modern Economy: Lessons from Medieval Trade*, Cambridge, UK: Cambridge University Press.
Grosjean, P., 2011. The Weight of History on European Cultural Integration: A Gravity Approach. *American Economic Review*, 101(3), pp.504–508.
Grossman, G.M. & Helpman, E., 1991. Quality Ladders in the Theory of Growth. *Review of Economic Studies*, 58(1), pp.43–61.
Guedes, J. d'Alpoim et al., 2013. Is Poverty in Our Genes? A Critique of Ashraf and Galor "The 'Out of Africa' Hypothesis, Human Genetic Diversity, and Comparative Economic Development." *Current Anthropology*, 54(1), pp.71–79.
Guiso, L., Sapienza, P. & Zingales, L., 2003. People's Opium? Religion and Economic Attitudes. *Journal of Monetary Economics*, 50(1), pp.225–282.
Guiso, L., Sapienza, P. & Zingales, L., 2004. The Role of Social Capital in Financial Development. *American Economic Review*, 94(3), pp.526–556.
Guiso, L., Sapienza, P. & Zingales, L., 2006. Does Culture Affect Economic Outcomes? *Journal of Economic Perspectives*, 20(2), pp.23–48.
Hall, R.E. & Jones, C.I., 1999. Why Do Some Countries Produce So Much More Output Per Worker Than Others? *Quarterly Journal of Economics*, 114(1), pp.83–116.
Harrod, R.F., 1939. An Essay on Dynamic Theory. *Economic Journal*, 49(193), pp.14–33.
Hobson, J.M., 2004. *The Eastern Origins of Western Civilisation*, Cambridge, UK: Cambridge University Press.
Hoffman, P.T., 2015. *Why Did Europe Conquer the World?*, Princeton, NJ: Princeton University Press.
Howitt, P., 2000. Endogenous Growth and Cross-Country Income Differences. *American Economic Review*, 90(4), pp.829–846.
Inglehart, R. & Baker, W.E., 2000. Modernization, Cultural Change, and the Persistence of Traditional

Values. *American Sociological Review*, 65(1), pp.19–51.
Jablonka, E. & Lamb, M.J., 2014. *Evolution in Four Dimensions: Genetic, Epigenetic, Behavioral, and Symbolic Variation in the History of Life* 2nd ed., Boston, MA: MIT Press.
Jacob, M.C., 1997. *Scientific Culture and the Making of the Industrial West* 2nd ed., New York, NY: Oxford University Press.
Jones, C.I., 1997. On the Evolution of the World Income Distribution. *Journal of Economic Perspectives*, 11(3), pp.19–36.
Jones, E.L., 1981. *The European Miracle: Environments, Economies, and Geopolitics in the History of Europe and Asia*, Cambridge, UK: Cambridge University Press.
Jorgenson, D.W., Gollop, F.M. & Fraumeni, B.M., 1987. *Productivity and U.S. Economic Growth*, Cambridge, MA: Harvard University Press.
Jorgenson, D.W., 1995. *Productivity*, Cambridge, MA: MIT Press.
Kamarck, A.M., 1976. *The Tropics and Economic Development: A Provocative Inquiry into the Poverty of Nations*, Baltimore, MD: John Hopkins University Press.
Kander, A., Malanima, P. & Warde, P., 2014. *Power to the People: Energy in Europe Over the Last Five Centuries*, Princeton, NJ: Princeton University Press.
Katz, L. & Autor, D., 1999. Changes in the Wage Structure and Earnings Inequality. In O. Ashenfelter & D. Card, eds. *Handbook of Labor Economics, Vol. 3A*. Amsterdam, NL: Elsevier B.V.
Kehoe, P.J. & Perri, F., 2002. International Business Cycles with Endogenous Incomplete Markets. *Econometrica*, 70(3), pp.907–928.
Knack, S. & Keefer, P., 1995. Institutions and Economic Performance: Cross-country Tests Using Alternative Institutional Measures. *Economics & Politics*, 7(3), pp.207–227.
Knack, S. & Keefer, P., 1997. Does Social Capital Have an Economic Payoff? A Cross-Country Investigation. *Quarterly Journal of Economics*, 112(4), pp.1251–1288.
Koopmans, T.C., 1965. On the concept of optimal economic growth. *Pontificae Academiae Scientiarum Scripta Varia*, 28(1), pp.225–288.
Krusell, P. et al., 2000. Capital-Skill Complementarity and Inequality: A Macroeconomic Analysis. *Econometrica*, 68(5), pp.1029–1053.
Kuran, T., 2012. *The Long Divergence: How Islamic Law Held Back the Middle East*, Princeton, NJ: Princeton University Press.
Kuran, T., 2016. Legal Roots of Authoritarian Rule in the Middle East: Civic Legacies of the Islamic Waqf. *American Journal of Comparative Law*, 64, pp.419–454.
Landes, D.S., 1998. *The Wealth and Poverty of Nations: Why Some Are So Rich and Some So Poor*, New York, NY: W.W. Norton & Company.
Lee, J.Z. & Feng, W., 1999. *One Quarter of Humanity: Malthusian Mythology and Chinese Realities, 1700-2000*, Cambridge, MA: Harvard University Press.
Lipset, S., 1960. *Political Man: The Social Bases of Politics.*, Garden City, NY: Doubleday.
Lipsey, R.G., Carlaw, K. & Bekar, C., 2005. *Economic Transformations: General Purpose Technologies and Long-Term Economic Growth*, Oxford, UK: Oxford University Press.
Lucas, R.E., 1988. On the Mechanics of Economic Development. *Journal of Monetary Economics*, 22, pp.3–42.
Lucas, R.E., 1990. Why Doesn't Capital Flow from Rich to Poor Countries? *American Economic Review*, 80(2), pp.92–96.
Machiavelli, N., 1998. *Discourses on Livy* H. C. Mansfield & N. Tarcov, eds., Chicago, IL: University of Chicago Press.
Mankiw, G.N., Romer, D. & Weil, D.N., 1992. A Contribution to the Empirics of Economic Growth. *Quarterly Journal of Economics*, 107(2), pp.407–437.
Marks, R., 2002. *The Origins of the Modern World: A Global and Ecological Narrative*, Lanham, MD: Rowman & Littlefield.
Marshall, A., 1890. *Principles of Economics*, London, UK: Macmillan Publishers Ltd.
Martin, P.S., 1984. Prehistoric Overkill: The Global Model. In P. S. Martin & R. G. Klein, eds. *Quaternary Extinctions: A Prehistoric Revolution*. Tucson, AZ: University of Arizona Press, pp. 354–403.
Matsuyama, K., 2004. Financial Market Globalization, Symmetry-Breaking and Endogenous Inequality of Nations. *Econometrica*, 72(3), pp.853–884.

McCloskey, D.N., 2008. “You know, Ernest, the rich are different from you and me”: a comment on Clark’s “A Farewell to Alms.” *European Review of Economic History*, 12(2), pp.138–148.
McNeill, W., 1963. *The Rise of the West : A History of the Human Community*, Chicago, IL: University of Chicago Press.
Merton, R.K., 1938. Science, Technology & Society in Seventeenth-Century England. *Osiris*, 4, pp.360–632.
Milanovic, B., 2011. A Short History of Global Inequality: The Past Two Centuries. *Explorations in Economic History*, 48(4), pp.494–506.
Milanovic, B., 2012. Global Inequality Recalculated and Updated: The Effect of New PPP Estimates on Global Inequality and 2005 Estimates. *Journal of Economic Inequality*, 10(1), pp.1–18.
Mincer, J., 1974. *Schooling, Experience, and Earnings.*, New York, NY: Columbia University Press.
Mokyr, J., 2011. *The Enlightened Economy: Britain and the Industrial Revolution, 1700-1850*, London, UK: Penguin Books.
Montesquieu, C.L. de S. baron de L.B. et de, 1748. *De l’Esprit des Lois*, Genève, CH: Barrillot & Fils.
Morris, I., 2015. Foragers, Farmers, and Fossil Fuels: How Human Values Evolve, Princeton, NJ: Princeton University Press.
Nelson, R.R. & Phelps, E.S., 1966. Investment in Humans, Technological Diffusion, and Economic Growth. *American Economic Review*, 56(2), pp.69–75.
Nelson, R.R. & Winter, S.G., 1982. *An Evolutionary Theory of Economic Change*, Cambridge, MA: Harvard University Press.
von Neumann, J., 1945. A Model of General Economic Equilibrium. *Review of Economic Studies*, 13(1), pp.1–9.
North, D.C. & Thomas, R.P., 1973. *The Rise of the Western World: A New Economic History*, Cambridge, UK: Cambridge University Press.
North, D.C., 1994. Economic Performance Through Time. *American Economic Review*, 84(3), pp.359–368.
North, D.C., 1990. *Institutions, Institutional Change, and Economic Performance*, Cambridge, UK: Cambridge University Press.
Nunn, N. & Wantchekon, L., 2011. The Slave Trade and the Origins of Mistrust in Africa. *American Economic Review*, 101(7), pp.3221–3252.
Obstfeld, M. & Taylor, A.M., 2003. Globalization and Capital Markets. In M. D. Bordo, A. M. Taylor, & J. G. Williamson, eds. *Globalization in Historical Perspective*. University of Chicago Press.
Ohlin, B., 1967. *Interregional and International Trade* 2nd ed., Cambridge, MA: Harvard University Press.
Olsson, O. & Hibbs, D.A., 2005. Biogeography and Long-Run Economic Development. *European Economic Review*, 49(4), pp.909–938.
Parente, S.L. & Prescott, E.C., 1994. Barriers to Technology Adoption and Development. *Journal of Political Economy*, 102(2), pp.298–321.
Parthasarathi, P., 2011. *Why Europe Grew Rich and Asia Did Not: Global Economic Divergence, 1600-1850*, New York, NY: Cambridge University Press.
Perdue, P.C., 2005. *China marches west : the Qing conquest of Central Eurasia*, Cambridge, MA: Harvard University Press.
Persson, K.G., 2008. The Malthus delusion. *European Review of Economic History*, 12(2), pp.165–173.
Pomeranz, K., 2000. *The Great Divergence: China, Europe, and the Making of the Modern World Economy*, Princeton, NJ: Princeton University Press.
Przeworski, A. et al., 2000. *Democracy and Development: Political Institutions and Well-Being in the World, 1950-1990*, Cambridge, UK: Cambridge University Press.
Rebelo, S., 1991. Long-Run Policy Analysis and Long-Run Growth. *Journal of Political Economy*, 99(3), pp.500–521.
Ricardo, D., 1817. *On the Principles of Political Economy and Taxation*, London, UK: John Murray.
Richerson, P.J. & Boyd, R., 2005. *Not by Genes Alone: How Culture Transformed Human Evolution*, Chicago, IL: University of Chicago Press.
Rodrik, D., Subramanian, A. & Trebbi, F., 2004. Institutions Rule: The Primacy of Institutions Over Geography and Integration in Economic Development. *Journal of Economic Growth*, 9, pp.131–165.

Romer, P.M., 1986. Increasing Returns and Long-Run Growth. *Journal of Political Economy*, 94(5), pp.1002–1037.
Romer, P.M., 1987. Growth Based on Increasing Returns Due to Specialization. *American Economic Review*, 77(2), pp.56–62.
Romer, P.M., 1990. Endogenous Technological Change. *Journal of Political Economy*, 98(5), pp.71–102.
Sachs, J.D. & Warner, A., 1995. Economic Reform and the Process of Global Integration. *Brookings Papers on Economic Activity*, 1(1), pp.1–118.
Saint-Paul, G. & Verdier, T., 1993. Education, democracy and growth. *Journal of Development Economics*, 42, pp.399–407.
Samuelsson, K., 1961. *Religion and Economic Action*, New York, NY: Basic Books.
Schaltegger, C.A. & Torgler, B., 2010. Work ethic, Protestantism, and Human Capital. *Economics Letters*, 107(2), pp.99–101.
Schultz, T., 1964. *Transforming Traditional Agriculture.*, New Haven, CT: Yale University Press.
Schumpeter, J., 1942. *Capitalism, Socialism and Democracy*, London, UK: Harper & Brothers.
Segerstrom, P.S. et al., 1990. A Schumpeterian Model of the Product Life Cycle. *American Economic Review*, 80(5), pp.1077–1091.
Sokoloff, K.L. & Engerman, S.L., 2000. History Lessons: Institutions, Factor Endowments, and Paths of Development in the New World. *Journal of Economic Perspectives*, 14(3), pp.217–232.
Solow, R.M., 1956. A Contribution to the Theory of Economic Growth. *Quarterly Journal of Economics*, 70(1), pp.65–94.
Spolaore, E. & Wacziarg, R., 2009. The Diffusion of Development. *Quarterly Journal of Economics*, 124(2), pp.469–529.
Spolaore, E. & Wacziarg, R., 2013. How Deep Are the Roots of Economic Development? *Journal of Economic Literature*, 51(2), pp.325–369.
Swan, T.W., 1956. Economic Growth and Capital Accumulation. *Economic Record*, 32(2), pp.334–361.
Tawney, R., 1926. *Religion and the Rise of Capitalism*, New York, NY: Harcourt Brace and Co.
The Maddison Project, 2013. GDP per Capita 1-2010 AD. Available at: http://www.ggdc.net/maddison/maddison-project/home.htm.
Thoenig, M. & Verdier, T., 2003. A Theory of Defensive Skill-Biased Innovation and Globalization. *American Economic Review*, 93(3), pp.709–728.
Todd, E., 1983. *The Explanation of Ideology: Family Structure and Social Systems*, New York, NY: Blackwell Publishers Ltd.
Toynbee, A., 1934. *A Study of History, Vol III: The Growths of Civilizations*, London, UK: Oxford University Press.
Uzawa, H., 1961. Neutral Inventions and the Stability of Growth Equilibrium. *Review of Economic Studies*, 28(2), pp.117–124.
Ventura, J., 1997. Growth and Interdependence. *Quarterly Journal of Economics*, 112(1), pp.57–84.
Voth, H.-J., 2008. Clark's intellectual Sudoku. *European Review of Economic History*, 12(2), pp.149–155.
de Vries, J., 1994. The Industrial Revolution and the Industrious Revolution. *Journal of Economic History*, 54(2), pp.249–270.
Vries, P., 2010. The California School and Beyond: How to Study the Great Divergence? *History Compass*, 8(7), pp.730–751.
Vries, P., 2015. *State, Economy and the Great Divergence: Great Britain and China, 1680s-1850s*, New York, NY: Bloomsbury Academics.
Warr, B. et al., 2010. Energy use and economic development: A comparative analysis of useful work supply in Austria, Japan, the United Kingdom and the US during 100 years of economic growth. Ecological Economics, 69(10), pp.1904–1917.
Weber, M., 1930. *The Protestant Ethic and the Spirit of Capitalism*, London, UK: Allen & Unwin.
Williamson, O.E., 2000. The New Institutional Economics: Taking Stock, Looking Ahead. *Journal of Economic Literature*, 38(3), pp.595–613.
Wong, R. Bin, 1997. *China Transformed: Historical Change and the Limits of European Experience*, Ithaca, NY: Cornell University Press.
Wrigley, E.A., 2013. Energy and the English Industrial Revolution. *Philosophical Transactions of the*

Royal Society. Series A: Mathematical, physical, and engineering sciences, 371, pp.1–10.
Zak, P.J. & Knack, S., 2001. Trust and Growth. *Economic Journal*, 111(470), pp.295–321.