I Z A Institute
of Labor Economics
Initiated by Deutsche Post Foundation

DISCUSSION PAPER SERIES

IZA DP No. 17491

Unified Growth Theory: Engines of Growth and Inequality in the Wealth of Nations

Oded Galor

DECEMBER 2024

I Z A Institute
of Labor Economics

Initiated by Deutsche Post Foundation

DISCUSSION PAPER SERIES

IZA DP No. 17491

Unified Growth Theory: Engines of Growth and Inequality in the Wealth of Nations

Oded Galor
Brown University, NBER, CERP, IZA and CESifo

DECEMBER 2024

ISSN: 2365-9793

IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

Unified Growth Theory: Engines of Growth and Inequality in the Wealth of Nations*

What sparked humanity's leap from stagnation to prosperity? What lies at the core of inequality among nations? Unified Growth Theory explores the evolution of societies over the entire course of human history. It uncovers the universal wheels of change that have governed the journey of humanity, driven the growth process, and shaped inequality across the globe. The theory sheds light on two of the most fundamental mysteries surrounding this journey: (i) *The Mystery of Growth*—the origins of the dramatic transformation in human prosperity over the past two centuries, in the wake of millennia of near stagnation; and (ii) *The Mystery of Inequality*—the roots of the vast inequality in the wealth of nations. The theory suggests that forces operating in the distant past are central to the understanding of the uneven development across the globe and the design of effective policies that could promote economic growth and mitigate inequality.

JEL Classification: I25, J10, O10, 040, Z10

Keywords: growth, inequality, Unified Growth Theory, human capital, demographic transition, Malthusian epoch

Corresponding author:
Oded Galor
Department of Economics and Population Studies and Training Center
Brown University
64 Waterman St.
Providence, RI 02912
USA
E-mail: oded galor@brown.edu

* The author is grateful to the Editor, Larry Samuelson, for his valuable comments.

1. Introduction

The transition from an epoch of stagnation to an era of sustained economic growth signifies the onset of one of the most remarkable transformations in human history since the emergence of Homo sapiens in Africa nearly 300,000 years ago. On the heels of millennia of largely stagnant living standards across world regions, the past two centuries have marked the onset of a profound metamorphosis: life expectancy has more than doubled and global per capita income has soared fourteen-fold. The core impetus of human life -- historically indistinguishable from that of other species and driven by the pursuit of survival and reproduction -- has radically evolved, transforming the quality of life across the globe.

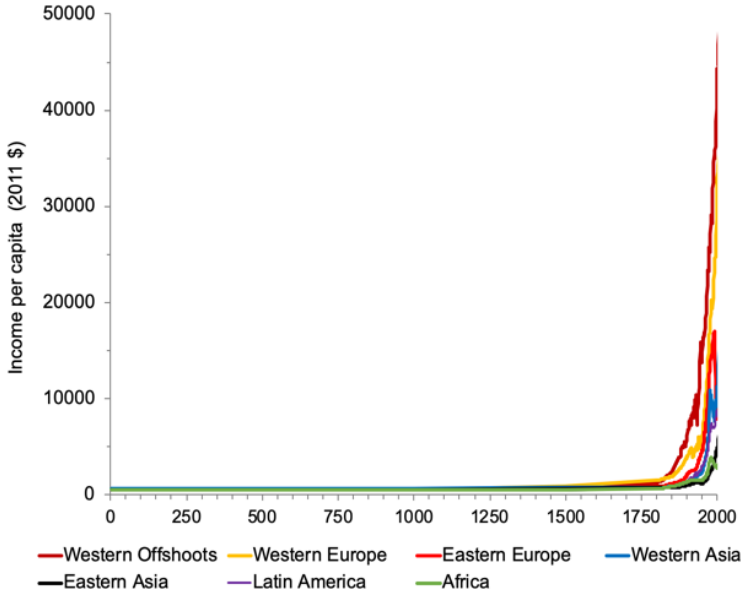

Figure 1. The Mystery of Growth

The dramatic spike in income per capita across world regions over the past two centuries, emerging from thousands of years of near stagnation.[1]

[1] Extrapolated based on data from Maddison Project Database 2010, 2013, 2018; Bolt and van Zanden (2014); and Bolt et al. (2018).

Yet, this transformation did not unfold uniformly across the globe. As prosperity skyrocketed in recent centuries, it occurred earlier in some parts of the world, triggering a second major transformation unique to the human species—the emergence of immense inequality across societies. Western European countries and some of their offshoots experienced the remarkable leap in living conditions in the nineteenth century, while this ascent was delayed in most regions until the latter half of the twentieth century, leading to a vast inequality across world regions.

What explains the *Mystery of Growth* – the extraordinary transformation in living standards over the last few centuries in the aftermath of the economic ice age that had defined most of human history since the advent of Homo sapiens? What accounts for the *Mystery of Inequality*—the origins of the significant disparity in the wealth of nations and the emergence of pronounced inequality across regions over the last two centuries?

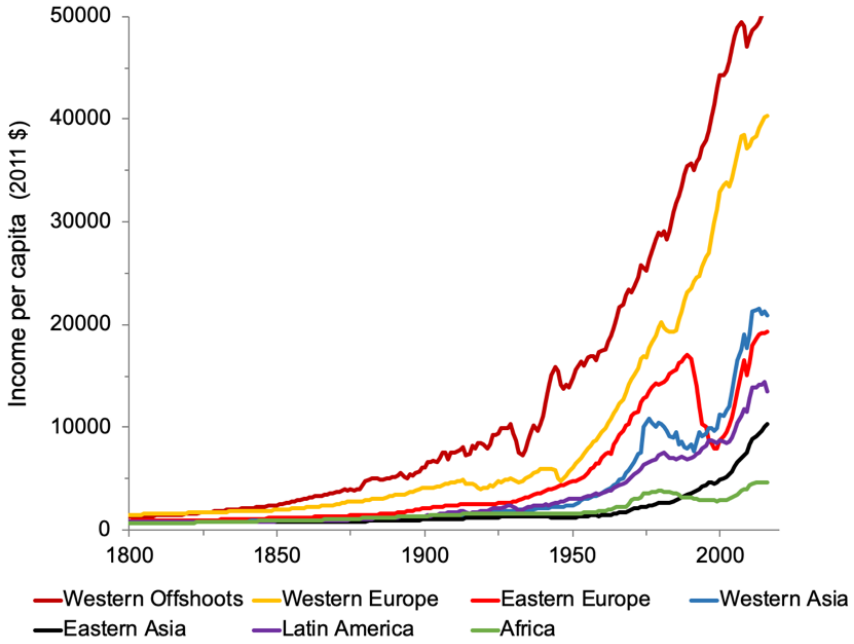

Figure 2. The Mystery of Inequality

The divergence in per capita income across world regions in the past two centuries.[2]

[2] Extrapolated based on data form Maddison Project Database 2010, 2013, 2018; Bolt and van Zanden (2014); and Bolt et al. (2018).

The transformation in societal well-being and the rise of global inequality have been shaped primarily by the onset and timing of the transition from stagnation to growth across societies, rather than by differences in their growth trajectories within the modern growth regime. Deep-rooted factors, operating over the course of human history, influenced the timing of this transformation and played a pivotal role in the remarkable leap in human prosperity and the emergence of profound inequality among nations.

2. Unified Growth Theory

2.1. Philosophical Foundations

Traditional growth models have been instrumental in advancing our understanding of the role of factor accumulation and technological progress in the growth process, highlighting their impact on convergence in living standards across nations.[3] Nevertheless, their exclusive focus on the modern growth regime inherently limits their ability to address the *Mystery of Growth* and the *Mystery of Inequality*. In particular, they largely overlook the forces that triggered the transition from stagnation to sustained economic growth, as well as the pivotal role that demographic patterns have played over the course of human history—insights essential for the understanding of the growth process and the origins of inequality among nations.[4]

In light of mounting evidence about the persistent effects of historical and prehistorical forces on the development process, the preoccupation of growth theory with societies that are 'parachuted' into the modern growth regime has become harder to justify. It has become apparent that as long as growth theory relies on distinct and disconnected models to characterize the process of

[3] The pioneering contributions to this earlier strand of growth theory include Solow (1956), Lucas (1988), Romer (1990), Grossman and Helpman (1991), and Aghion and Howitt (1992). While convergence is a central implication of many models in this tradition, initial conditions may still play a significant role, particularly in the presence of credit market imperfections and non-convexities (Galor and Zeira, 1993; Galor, 1996).

[4] Failure to account for demographic forces led to predictions that are inconsistent with key historical phases: (i) during the Malthusian Epoch, capital accumulation and technological progress was largely offset by population growth, resulting in negligible effects on the long-term level and growth rate of income per capita, and (ii) the fertility decline in the course of the demographic transition played a pivotal role in facilitating the transition to modern growth.

development during the epoch of stagnation and the modern growth regime, our understanding of the contemporary growth process will be incomplete and potentially distorted.

This challenge mirrors the scientific struggle faced by Nicolaus Copernicus, the Renaissance-era astronomer who revolutionized our understanding of the universe. Copernicus argued that without a unified theory to account for the operation of the universe, scientific knowledge would be fragmented and incomplete. "[I]t is as though an artist were to gather the hands, feet, head and other members for his images from diverse models, each part excellently drawn, but not related to a single body, and since they in no way match each other, the result would be a monster rather than a man" (as quoted in Kuhn, 1957).

Analogously, in recent decades, physicists have strived to establish a 'theory of everything'—a framework unifying all physical aspects of the universe by reconciling quantum mechanics with Einstein's theory of general relativity and encompassing the interactions of gravitational, electromagnetic, weak nuclear, and strong nuclear forces. This pursuit stems from the conviction that a comprehensive understanding of the physical aspects of the universe must rest on a single unified framework capable of concurrently explaining all known physical phenomena.

The development of unified growth theory was driven by a similar conviction that the understanding of the main engines of economic development would remain incomplete and fragile unless growth theory encompassed the primary driving forces throughout the entire process of development. The theory emerged from the realization that fragmented economic growth models—those treating the modern era of economic growth and the epoch of stagnation as distinct, separate phenomena rather than interconnected parts of a unified whole--were inherently limited in their ability to explain the overarching historical forces that have shaped the contemporary growth process and the vast global disparities in societal well-being.

Unified Growth Theory (Galor, 2005, 2010, 2011, 2022) has addressed these formidable challenges, providing a unified analytical framework that encompasses the evolution of societies over the entire span of human existence, linking the historical engines of growth with contemporary prosperity and inequality. The theory uncovers the universal 'wheels of change'

that have governed the journey of humanity across all regions of the planet. It identifies and traces the forces that constrained the human species to an epoch of subsistence-oriented existence, while ultimately triggering the onset of the momentous transition from an epoch of stagnation to an era of sustained growth and the resulting divergence in the wealth of nations.

Leveraging this novel comprehensive framework, the theory captures the endogenous progression of technology, the size and the composition of the human population, and income per capita over the entire course of history. It integrates the key characteristics of the development process into a single analytical framework, encompassing: (i) the epoch of stagnation that defined most of human history; (ii) the escape from this trap, marked by spikes in income per capita and population growth; (iii) the emergence of human capital formation as a pivotal engine of economic growth; (iv) the catalysts for the onset of the dramatic fertility decline in the course of the demographic transition; (v) the shift to the contemporary era of sustained economic growth; and (vi) the divergence in prosperity across countries in recent centuries.[5] The theory reveals the principal economic forces that have driven the remarkable transition from stagnation to growth, highlighting their importance for the understanding of the contemporary growth processes of both developed and less developed societies. Furthermore, it sheds light on the role of historical and prehistorical factors in shaping the divergence of income per capita across world regions over the past two centuries.

The unique power of Unified Growth Theory lies in its ability to distill the complex and often chaotic currents of history, uncovering the fundamental forces that have universally governed the journey of humanity across every region of the world. Human history is rich with countless fascinating details: mighty civilizations that rose and fell, charismatic emperors who led armies to sweeping conquests and defeats, artists who created captivating cultural treasures, and

[5] In light of its philosophical foundations, the term *Unified Growth Theory*, introduced by Galor (2005), refers to growth models that integrate the entire growth process into a unified framework, capturing: (i) the endogenous evolution of technology, population, and income per capita throughout human history; (ii) the era of Malthusian stagnation; (iii) the endogenous transition out of the Malthusian trap; (iv) the onset of the demographic transition; and (v) the emergence of sustained economic growth. Some models capture segments of the broader process (e.g., Fernandez-Villaverde, 2001; Hazan and Berdugo, 2002; Doepke, 2004; Cervellati and Sunde, 2005; Voigtländer and Voth, 2006; Boucekkine et al., 2007; de la Croix and Licandro, 2013; and Dalgaard and Strulik, 2015), while others rely on exogenously specified demographic trends and technological trajectories (Hansen and Prescott, 2002; and Parente and Prescott, 2005) or external shocks (Lagerlöf, 2003).

philosophers and scientists who advanced our understanding of the universe. It is easy to become adrift in this ocean of details, pounded by the waves and unaware of the mighty currents underneath.

Instead, Unified Growth Theory explores the underlying forces that have shaped the journey of humanity. It reveals how these forces operated persistently during the prolonged economic ice age, gradually building momentum while exerting limited impact on income per capita. However, as technological advancements surpassed a critical threshold during the Industrial Revolution, rudimentary education became essential for navigating the rapidly changing landscape. Fueled by expanding parental resources, population growth surged. Over time, as parental investment progressively shifted toward human capital formation, technological progress began to outpace population growth, generating rising rates of both income per capita and population growth. Ultimately, rising demand for human capital led to a sharp decline in fertility rates, liberating the growth process from the counterbalancing effects of population expansion, and paving the way for enduring prosperity.

This is not the first attempt to describe the core thrust of human history. Great thinkers such as Plato, Hegel, and Marx argued that history unfolds according to inescapable universal laws, often disregarding the role of societies in shaping their own destinies (Popper, 1945). In contrast, Unified Growth Theory neither posits an inexorable march of humanity toward utopia or dystopia, nor seeks to derive moral insights about the desirability of the direction of this journey and its consequences. Instead, it is designed to provide a faithful, scientifically grounded, and interdisciplinary theoretical framework for the understanding of the evolution of societies since the emergence of Homo sapiens.

2.2. Phases of Development

Throughout most of human history, the development process was dominated by Malthusian dynamics. Technological progress and land expansion fueled rising birth rates and declining mortality rates, ultimately leading to proportional increases in both population and resources. Variations in technological progress and land productivity across societies contributed to

differences in population densities but had only short-term effects on living standards.[6] Yet, larger populations were more likely to give rise to ingenious individuals capable of developing new tools, goods, and practices (Simon, 1977; Kremer, 1993; and Galor, 2022), while also generating a greater demand for these innovations (Boserup, 1965). Moreover, sizable societies benefited from increased specialization and cross-fertilization, facilitating the rapid dissemination of new technologies.

This self-reinforcing feedback loop between population and technology emerged at the dawn of humanity and persisted over most of human history. Technological advances enabled larger populations to be sustained, while increasing population size spurred faster innovations. Nevertheless, during the Malthusian epoch, technological progress was ultimately counterbalanced by population growth, leaving income per capita hovering near the subsistence level in the long run.

Just a few centuries ago, human life was often "nasty, brutish, and short" (Hobbes, 1651). One in four newborns succumbed to cold, hunger, or illness before reaching their first birthday. Women frequently died during childbirth, and life expectancy rarely surpassed forty years. Most people subsisted on meager, monotonous diets and lived in a state of widespread illiteracy. Amid these grim realities, perhaps even more startlingly, economic crises did not merely demand austerity—they often triggered widespread starvation and societal collapse.

Remarkably, most people endured conditions more akin to those of their distant ancestors millennia earlier than to those of their modern descendants. The living conditions of a fifteenth-century English farmer were strikingly similar to those of a medieval Chinese serf or a Mayan

[6]Empirical investigations rooted in the framework of Unified Growth Theory lend credence to the validity of Malthusian dynamics and the phenomenon of Malthusian stagnation. These findings are based on (a) cross-country evidence from 1–1500 CE (Ashraf and Galor, 2011), (b) time-series data for 17 countries spanning 900–1870 CE (Madsen et al., 2019), (c) quantitative analysis of pre-industrial European societies from 1300–1800 CE (Lagerlöf, 2019), and (d) within-country studies of pre-industrial societies, including (i) China (Chen and Kung, 2016), (ii) England (Klemp, 2012; Møller and Sharp, 2014; and Attar, 2023), (iii) Germany (Pfister and Fertig, 2020), (iv) Italy (Fernihough, 2013), (v) Spain (Chaney and Hornbeck, 2016), (vi) Sweden (Lagerlöf, 2015), and (vii) Denmark, Sweden, and Norway (Klemp and Møller, 2016).

peasant. Similarly, they closely resembled those of an ancient Greek herder, an Egyptian farmer, or even a shepherd in Jericho at the dawn of the Neolithic Revolution.

Ironically, just as Malthus (1798) declared this "poverty trap" to be an inescapable, perpetual human condition, the underlying dynamics he identified began to shift, triggering a profound transition from stagnation to growth. In recent centuries, many regions across the globe have escaped the Malthusian trap, experiencing substantial improvements in living standards. The sharp decline in population growth during the demographic transition disrupted the Malthusian dynamics, liberating the growth process from the counterbalancing effects of a rising population. Technological progress and human capital formation, at last, paved the way for an era of sustained economic growth. However, this remarkable progress was uneven, and as prosperity soared in recent centuries, it emerged earlier in some regions than others, fueling significant inequality across societies.

In the wake of these profound transformations, fundamental conundrums arise: What were the underlying causes of this prolonged epoch of stagnation? How did humanity manage to escape this poverty trap? Could the forces that governed the enduring economic ice age, and the eventual escape from it, have brought it to an end and lie at the root of the vast inequalities in living conditions across the globe today?

Unified Growth Theory uncovers the central forces that gave rise to the Malthusian trap, unraveling the mechanisms that ultimately enabled humanity to escape its gravitational pull. What are the underlying causes of this prolonged epoch of stagnation that defined most of human history? Why did episodes of technological progress in the pre-industrial era fail to spark sustained economic growth? Why did population growth consistently counterbalance the potential per capita gains from technological advances? And were changes in the size and the composition of the human population during the Malthusian epoch pivotal in enabling the eventual escape from this trap?

The theory uncovers the forces that sparked the transition from stagnation to growth, deciphering the mechanisms behind this profound transformation. What caused the sudden surge in income

per capita over the past few centuries? What explains the marked reversal of the long-standing positive relationship between income per capita and population growth, which persisted throughout most of human history? Could the transition to sustained economic growth have occurred without the significant decline in fertility during the demographic transition? And what barriers do less-developed economies face in their pursuit of a sustained growth regime?

Moreover, Unified Growth Theory offers new insights into the origins of the stark widening disparity between developed and developing regions over the past two centuries. Are human societies inherently constrained by the history and geography of the regions in which they emerged? What sparked the rapid shift from stagnation to growth in some countries, while others remain mired in persistent stagnation? Why has the demographic transition taken place more than a century earlier in some economies compared to others? Has the transition to sustained economic growth in advanced economies adversely impacted the development process in poorer regions? What role do deeply rooted institutional, cultural, and societal factors play in driving the divergence in the wealth among nations? And have historical and prehistorical conditions left a lasting imprint on global economic development?

2.3 Challenges and their Resolution

Developing a unified analytical framework that captures the distinct phases of development while facilitating a seamless, endogenous transition between the various regimes required significant methodological and conceptual innovations. These advancements were crucial for designing a dynamical system that enables: (i) a spontaneous escape from the globally stable Malthusian equilibrium, which had dominated much of human history, and (ii) a reversal of the positive link between parental resources and reproductive success, leading to a marked fertility decline that liberated the growth process from the counterbalancing effects of population growth.

2.3.1 Orchestrating an Escape from the Malthusian Trap

During the Malthusian epoch, deviations from the long-run level of income per capita—driven by innovations, territorial expansion, and institutional or epidemiological changes—triggered a

powerful population response that drove per capita income back to its historical norm. What forces, then, propelled humanity beyond the bounds of the Malthusian equilibrium? How did the world manage to escape the grasp of the Malthusian octopus and the economic black hole?

In the quest to identify the catalyst behind the transition from stagnation to growth, one might be tempted to view the Industrial Revolution as an external shock that abruptly propelled the world out of the gravitational pull of the Malthusian equilibrium and into the modern era of economic growth. However, evidence from the eighteenth and nineteenth centuries reveals that productivity gains during this period unfolded gradually, not as a sudden, transformative leap (Crafts and Harley, 1992). On the eve and in the early phases of the Industrial Revolution, technological advancements were incremental, sparking population surges and modest increases in income per capita. Yet, nearly a century later, Malthusian forces had dissipated, and population growth had slowed, paving the way for an unprecedented economic expansion.

This gradual yet significant transition presents a major theoretical challenge. The simplest method for generating such a phase transition—a major shock within a dynamical system characterized by multiple locally stable equilibria—fails to adequately account for the observed take-off from stagnation to growth. A unified theory of economic growth, therefore, necessitates the creation of a dynamical system that enables economies to transition gradually yet swiftly from a stable (absorbing) Malthusian equilibrium. Paradoxically, however, this appears to contradict the essence of a stable equilibrium, where dominant attractive forces should preclude a gradual escape.

Unified Growth Theory provides a conceptual framework that addresses this conundrum, facilitating an escape from a stable Malthusian equilibrium. It builds on the understanding that in multi-dimensional nonlinear dynamical systems, when a single variable crosses a critical threshold, it can trigger a sudden and profound transformation in the system's qualitative structure, potentially causing a stable equilibrium to vanish and a new one to emerge.[7] Unified Growth Theory identifies the underlying forces that gained momentum throughout the Malthusian epoch

[7] Bifurcation Theory demonstrates that as a single parameter crosses a critical threshold, it can trigger a qualitative transformation in a nonlinear dynamical system, leading to the disappearance of existing stable equilibria and the emergence of new ones.

and eventually reached a critical threshold, beyond which the gravitational forces of the Malthusian equilibrium dissipated. These forces enabled an escape from what had been a perpetually stable equilibrium.

The reinforcing interaction between technological progress and the size and composition of the population operated persistently throughout history, gradually gaining momentum. Nevertheless, for most of human history, this interaction had a largely negligible long-term impact on income per capita. Eventually, however, as the pace of technological advancement accelerated beyond a critical threshold, education became essential for navigating the rapidly evolving technological landscape, prompting parents to allocate some of their limited resources to their children's education. Although technological progress increased parental income, enabling a surge in fertility and population growth,[8] the allocation of resources toward children's human capital caused population growth to lag behind technological progress, fueling the onset of economic growth.

Yet, the growth in income per capita remained largely constrained by population expansion. It was the dramatic decline in fertility rates that liberated the economy from the counterbalancing effects of population growth, paving the way for an era of sustained economic development. What, then, enabled the puzzling reversal of the positive link between parental resources and reproductive success—a relationship evident in other species?

2.3.2 Triggering a Fertility Decline Despite the Rise in Income

During the Post-Malthusian Regime, technological progress produced conflicting effects on fertility rates. The rise in income alleviated subsistence consumption constraints, allowing households to allocate additional resources toward raising children—an income effect. Meanwhile, the modest demand for human capital prompted a reallocation of resources toward child quality—a substitution effect. Given the moderate strength of the substitution effect, the income effect dominated, enabling households to increase both the number and the quality of their children.

[8] Technically, individuals face a subsistence consumption constraint below which survival is not feasible. Rising wages allow parents to spend less time meeting this constraint, enabling the allocation of more time to child-rearing, thus increasing the number of children.

The empirically grounded theoretical feature that ultimately facilitates the reversal of the positive link between parental resources and reproductive success is the pivotal role assigned by Unified Growth Theory to human capital in navigating a rapidly changing technological environment. As technological acceleration persisted during industrialization, the return on investment in human capital surged, resulting in the dominance of the substitution effect, despite the rise in income. Households inevitably shifted their resources toward child quality, triggering a decline in fertility rates, and reversing the long-standing positive association between income and reproductive success.[9]

3. The Wheels of Change

What are those forces—the wheels of change—that operated relentlessly during the Malthusian epoch and ultimately triggered: the escape from the Malthusian trap; the emergence of human capital as a major engine of growth; the reversal of the positive association between income and reproductive success; and the dramatic transformation in living standards over the past two centuries?

These forces, subtle and unassuming at first, gathered strength over time, much like the gradual intensification of heat in a kettle of water placed over a steady flame. Initially, the surface of the water reveals no visible signs of change—it remains calm, as though the gradual rise in temperature has no discernible effect. Yet this tranquility is deceptive. As the water's molecules absorb heat

[9] The model assumes that individuals derive utility from consumption, the number of children, and their quality, all of which are normal goods. Higher child quality increases the likelihood of children reaching reproductive age. Individuals face a subsistence consumption constraint, below which survival is impossible, and child-rearing requires parental time. In the Malthusian epoch, rising income reduced the time needed to meet subsistence requirements, allowing parents to raise more children. As societies escape the Malthusian trap, rising earned income—driven by technological progress—introduces conflicting income and substitution effects: higher income encourages fertility, but it also raises the opportunity cost of child-rearing, which discourages fertility. If preferences are homothetic, these effects offset each other, keeping total investment in child quantity and quality unchanged. However, as technological progress accelerates, parental time becomes more effective in fostering quality children, leading to increased investment in quality and a decline in fertility. For a more detailed technical discussion, the reader is referred to Chapter 5 of Galor (2011).

and their bonds weaken, their movement accelerates. Eventually, upon reaching a critical temperature, the water undergoes a sudden phase transition from liquid to gas.

Over the past two centuries, humankind has experienced a comparable phase transition. Much like the transformation of water in a kettle from liquid to gas, this shift marked the culmination of a process that had been steadily intensifying beneath the surface over hundreds of thousands of years of economic stagnation. While the transition from stagnation to growth may appear dramatic and sudden—and indeed it was—the underlying forces driving this change were set in motion at the dawn of humanity, gradually gathering momentum over the course of history. What, then, sparked this remarkable phase transition?

Figure 3: Phase Transition

Illustrator: Ally Zhu

3.1. Reinforcing Interaction between Population Size and Technological Progress

The interplay between population growth and technological progress formed a self-reinforcing cycle in the course of human history. Over the 12,000 years from the Neolithic Revolution to the onset of the industrial era, technological advances drove a 400-fold expansion in population. This growing population, in turn, accelerated innovation, propelling the leap of humanity from stone tools in the early stages of development to the steam engine technology that defined the initial phases of the Industrial Revolution.

In the pre-industrial era, advancements in farming techniques and cultivation methods improved diets and living conditions, spurring population growth, driven by higher birth rates and lower mortality. However, as arable land grew scarcer, the expanding population diminished the per capita share of crops, causing living standards to decline and ultimately stabilize only once the amount of crops per person returned to its initial level. Thus, while technological progress enabled population growth, it failed to produce a lasting impact on human prosperity.

The remarkable growth of the human population has shaped societies and civilizations. At the dawn of the Neolithic Revolution around 10,000 BCE, approximately 2.4 million people inhabited the Earth. When the Roman Empire and the Mayan Civilization reached their zenith around 1 CE, the global population had surged 78-fold, reaching 188 million. A thousand years later, amidst Viking raids in Northern Europe and the first recorded use of gunpowder in China, the population had grown to 295 million. In 1500, during the height of Columbus's expeditions to the Americas, the world's population had nearly reached half a billion, and as the 19th century began and industrialization took hold, humanity was on the verge of surpassing the one-billion mark.

This impact of population size on technological advancement is evident across cultures and regions throughout the historical record. Regions that experienced an earlier onset of the Neolithic Revolution, such as the Fertile Crescent, saw the emergence of the largest prehistoric settlements and maintained a persistent technological head start. Similarly, areas with land more suitable for agriculture—and consequently higher population densities—were more likely to develop advanced technologies (Diamond, 1997)."

The mutually reinforcing relationship between technological progress and population size over the course of human history accelerated the pace of innovation until it eventually reached a critical threshold, culminating in a phase transition.[10] As technology advanced at an unprecedented pace, human capital became vital for navigating the rapidly evolving economic landscape. The growing demand for human capital encouraged parents to allocate their limited resources to educating fewer children. This fertility decline alleviated the counterbalancing effects of population growth, paving the way for the emergence of sustained economic growth.

This interaction between two of the wheels of change–technological progress and the size of the population–was one of the sparks that ignited the monumental phase transition experienced by humanity, lifting humankind out of an epoch of stagnation (Galor and Weil, 2000).[11]

3.2. Reinforcing Interaction between Adaptation and Technological Progress

The interplay between the composition of the population and technological progress established an additional self-reinforcing cycle over the course of human history. As technological advances periodically alleviated Malthusian pressures, they not only expanded the population but also reshaped its composition. Individuals whose intergenerationally transmitted traits complemented the evolving technological landscape achieved higher incomes and, during the Malthusian epoch, experienced greater reproductive success, leading to the increased prevalence of their traits in the population. The gradual increase in the dominance of these complementary traits further spurred technological innovation and drove additional changes in the composition of the population, ultimately facilitating the transition from stagnation to sustained growth.[12]

---

[10] The reinforcing interaction between population and technology during the Malthusian and the post-Malthusian era is supported by a large range of anecdotal evidence (Boserup, 1965); Simon, 1977); Kremer, 1993); and Galor, 2022), as well as time series analysis (Madsen et al., 2010).

[11] For a quantitative analysis of this model, refer to (Lagerlöf, 2006).

[12] One might question whether significant evolutionary changes could occur rapidly enough to be relevant to our understanding of the process of economic development. While certain evolutionary developments, such as the emergence of complex organs, unfolded over millions of years, the composition of traits within a population can shift rather rapidly. Notably, natural immunity to local diseases emerged after the Neolithic Revolution, enhancing resistance to infections; the ability to metabolize regional food sources, such as lactose, evolved in populations where cows, goats, and sheep were domesticated; and adaptation to long-term high-altitude living arose in certain populations Moreover, cultural evolution may occur at a much faster pace (Galor, 2022).

The Malthusian environment catalyzed the evolution of growth-enhancing traits and cultural norms—including a predisposition toward investment in human capital, a future-oriented mindset, and an entrepreneurial spirit (Galor and Moav, 2002; Galor and Michalopoulos, 2012; Galor and Ozak, 2016).[13] The gradual proliferation of these traits accelerated technological progress, creating a reinforcing cycle that laid the foundation for a transformative rise in human prosperity.

This process is epitomized by the evolution of parental predisposition toward child quality. The Neolithic Revolution facilitated the division of labor and fostered trade relationships among individuals and communities, enhancing the complexity of human interaction and raising the return to human capital. Individuals born to parents with moderately greater predisposition toward offspring quality generated higher income and, during the Malthusian epoch—when reproductive success was positively affected by aggregate resources—a larger number of offspring. Consequently, a moderately greater predisposition toward child quality gained an evolutionary advantage, increasing its prevalence within the population over time. As this trait gradually spread, it further accelerated the pace of technological advancement, ultimately facilitating the transition from stagnation to growth (Galor and Moav, 2002).[14]

The extensive genealogical records of nearly half a million descendants of European settlers in Quebec from 1608 to 1800 provide a unique demographic laboratory for the examination of this theory. Tracking the offspring of the founding populations over four generations reveals an intriguing pattern: the largest dynasties originated from moderately fertile settlers, who had a modest number of children while investing proportionally more in their children's human capital. In contrast, highly fertile founders, who had larger families, invested less in each child, and had fewer descendants after several generations. The evidence suggests that a moderate number of children per family resulted in a greater number of descendants after several generations, due to

[13] The economic incentives that emerged during the Industrial Revolution further fostered the prevalence of an entrepreneurial spirit (Doepke and Zilibotti, 2008).

[14] Indeed, recent analysis of ancient DNA suggests that the predisposition toward education has gradually increased in the past 9,000 years, since the Neolithic Revolution, among Western Asian and European populations (Akbari et al., 2024).

the impact of smaller family sizes on each child's likelihood of survival, marriage, literacy acquisition, and reproduction (Galor and Klemp, 2019).[15]

The conditions faced by the founding population of Quebec during this period of high fertility mirror those encountered by humans during their dispersal across the planet in at least one fundamental aspect: settling in environments with a carrying capacity far exceeding the size of the founding population**.** Extrapolating from this evidence**,** one can plausibly infer that during periods of high fertility in the Malthusian epoch changes in the composition of the population occurred more rapidly, and the prevalence of individuals inclined to invest more in human capital progressively intensified.

Thus, the reciprocally reinforcing relationship between technological progress and human adaptation throughout history reshaped the composition of the human population, increasing the prevalence of growth-enhancing traits. This transformation accelerated the pace of innovation until it reached a critical threshold, triggering a phase transition. As technology advanced at an unprecedented rate, human capital became essential for navigating the rapidly evolving economic landscape. The rising demand for human capital prompted parents, regardless of their predisposition toward education, to raise fewer children and to invest more of their limited resources in their human capital. This fertility decline mitigated the counterbalancing effects of population growth, paving the way for the sudden emergence of sustained economic growth.

The interaction between these two wheels of change—technological progress and human adaptation—was an additional spark that ignited the transformative phase transition, propelling humankind out of an epoch of stagnation, irrespective of population size (Galor and Moav, 2002).[16]

3.3. Regional Variations in the Rotation of the Wheels of Change

[15] This evidence from England between 1541 and 1851 reveals a comparable pattern: families that allocated greater resources toward their children's human capital saw a higher number of their offspring survive into adulthood (de la Croix et al., 2019).
[16] For a quantitative analysis of this model, refer to Collins et al (2014).

The wheels of change have governed the development process throughout human history across all world regions. Technological innovations enabled population growth and spurred adaptation to an evolving technological landscape. In turn, larger and more adapted human populations enhanced human capacity to develop new technologies and exert greater control over their surroundings. Collectively, these forces catalyzed a phase transition that liberated humanity from the enduring grip of the Malthusian trap. This transformation unleashed an unparalleled wave of innovation, fostering human capital formation, a reduction in fertility rates, and a dramatic rise in living standards.

Yet, the pace of interaction between technological progress and the size and the composition of the population has varied significantly across societies. Various historical factors—including institutional, cultural, geographical, and societal characteristics, as well as the legacy of colonialism—have influenced the speed of these self-reinforcing processes and generated distinct timelines for the emergence of the modern growth regime. Notably, societies that safeguarded property rights, embraced forward-looking mindsets, fostered knowledge diffusion, and exhibited a greater propensity for trade, experienced a more rapid transition from stagnation to growth (Galor, 2010, 2011, 2022).

Uneven development has been intensified in an increasingly interdependent world. Notably, trade during the colonial era played a pivotal role in the differential timing of demographic transitions across nations, influencing global population distribution and widening the gap in income per capita between countries (Galor and Mountford, 2006, 2008). The expansion of international trade prompted industrial economies to specialize in the production of skill-intensive goods. The resulting demand for skilled labor led to increased investment in human capital, hastening the onset of their demographic transitions and expediting their shift to the modern growth regime. In contrast, international trade incentivized nonindustrial economies to focus on the production of unskilled labor-intensive goods. The limited demand for human capital in these regions diminished investment in education and skills, delaying their demographic transitions and prolonging their periods of economic stagnation.[17]

[17] Using a panel of 223 countries spanning the period 1962–2019, Ekanayake et al. (2023) presents evidence supporting this differential effect of trade on fertility and education. Technological diffusion is an additional critical factor in the determination of comparative development in an interdependent world (Cervellati et al., 2023).

4. Reconstructing Human History Through the Lens of Unified Growth Theory

The journey of humanity has been extraordinary—remarkable in its trajectory and profoundly distinct from the evolution of other species on planet Earth. The pivotal factor that set humanity on its unique course was the human brain, whose growing capabilities arose from evolutionary pressures specific to our species. Armed with powerful cognitive abilities and the capacity for social cooperation and communication, humans gradually developed more advanced technologies, enhancing their efficiency in hunting and gathering, exploiting diverse habitats and broadening their material base. This resource expansion spurred population growth, conferring a survival advantage to individuals whose traits enhanced their ability to advance and harness these novel technologies. Thus emerged Homo technologicus: humans with hands adapted to craft tools for hunting and cooking, arms evolved to throw spears, and brains advanced to innovate, strategize, and facilitate cooperation and complex trade relations.

Over hundreds of thousands of years, the mutually reinforcing interaction between technological advancements and human adaptation progressively enhanced humanity's ability to thrive in an ever-changing environment. As humans flourished and expanded, they eventually ventured out of Africa, spreading across the globe and occupying new ecological niches. They learned to protect themselves from harsh climatic conditions, refined their hunting and gathering techniques across diverse habitats, and thereby experienced further population growth.

Nearly 12,000 years ago, humanity underwent its first major transformation—the Neolithic Revolution—markedly altering the course of human history. In just a few thousand years, much of the human population abandoned their nomadic lifestyle and embraced sedentary agriculture: cultivating land, raising livestock such as cattle, sheep, and goats, and adapting to new stationary environments. Technological innovations such as irrigation and improved farming techniques boosted agricultural yields and supported growing population densities. The expanding population

fostered specialization and triggered the emergence of a non-food-producing class dedicated to the advancement of writing, art, and scientific exploration, fueling further technological progress and establishing an enduring technological head start.

The human landscape gradually transformed: farms evolved into villages, and villages expanded into towns and walled cities. These cities gave rise to magnificent palaces, temples, and fortresses—strongholds of elites who built formidable armies and waged bloody battles for land, prestige, and power.

For most of human history, the interplay between technological progress, population growth, and human adaptation formed a self-reinforcing cycle. Technological advancements fueled population expansion and intensified the adaptation of societal traits to these innovations. In turn, population growth and societal adaptation broadened the pool of inventors and expanded the demand for new technologies, further driving their creation and adoption. For millennia, these underlying forces propelled humanity forward: technologies advanced, populations grew, and societies adapted—triggering continuous progress across civilizations.

Nevertheless, one fundamental aspect of the human condition remained largely unchanged: the quality of life. For much of human history, technological progress failed to produce significant long-term improvements in living standards. Instead, technological advancements and resource expansion primarily fueled population growth, diluting the benefits of progress as they were divided among an ever-increasing population. Although innovations occasionally brought short-term gains in economic prosperity, these were ultimately offset by population growth, causing living conditions to revert toward subsistence levels. Fertile land and political stability—such as in ancient China, Egypt, Greece, Persia, and Rome—often facilitated substantial technological advancements, temporarily raising living standards as new tools and production methods spread. Yet, such improvements were invariably short-lived.

Eventually, however, the accelerating interaction of the wheels of change propelled the pace of technological advancement beyond a tipping point. The rapid innovations of the Industrial Revolution, which emerged in regions of northern Europe during the eighteenth and nineteenth

centuries, created demand for a novel resource: the skills and knowledge necessary for workers to navigate an ever-evolving technological landscape.[18]

The increasing demand for educated workers capable of navigating the rapidly evolving technological landscape contributed significantly to the formation of human capital. As a growing number of occupations in manufacturing, trade, and services required literacy, numeracy, arithmetic, and a range of mechanical abilities, parents were incentivized to invest in their children's education. With parental resources gradually channeled toward human capital formation, the rate of population growth began to lag behind technological progress, contributing to rising income per capita and population growth rates. Ultimately, however, the intensification of the demand for human capital forced parents to dramatically reduce their fertility rates so as to permit further investment in the education of children, leading to the dramatic decline in fertility that characterized the demographic transition (Galor and Weil, 2000; Galor and Moav, 2002; and Galor and Mountford, 2008).[19] The surge in life expectancy and reduction in child mortality extended the period over which returns to education could be realized, further enhancing the incentive to invest in human capital and reduce fertility rates (Galor and Weil, 1999; and Cervellati and Sunde, 2005). The impact of technology-skill complementarity on narrowing the gender wage gap increased the opportunity cost of child-rearing, further promoting smaller family sizes (Galor and Weil, 1996). These combined forces ignited the demographic transition, breaking the longstanding positive relationship between economic growth and birth rates.[20]

[18] The impact of a rapidly evolving technological landscape on the returns to human capital is a central conceptual paradigm underlying this mechanism, as well as those explored in Galor and Tsiddon (1997); Galor and Moav (2000); and Hassler and Rodriguez-Mora (2000). Evidence suggests that during the early stages of industrialization, the complementarity between technology and skill is evident in England (De Pleijt et al., 2020), France (Squicciarini and Voigtländer, 2015; and Franck and Galor, 2021, 2022), and Germany (Becker et al., 2011), prompting significant education reforms (Galor and Moav, 2004, 2006; and Galor et al., 2009). More broadly, studies indicate that educated individuals possess a comparative advantage in coping with rapidly changing technological environments (e.g., Schultz, 1975; Foster and Rosenzweig, 1996). Moreover, evidence suggests that education was a dominant driver of the British economy's growth from 1270 to 2010 (Madsen and Murtin, 2017).

[19] Cultural factors have played a pivotal role in shaping the onset of declining fertility rates (Spolaore and Wacziarg, 2016). The early decline in fertility in mid-18th century France—nearly a century ahead of other Western European countries—is widely attributed to cultural influences (Blanc, 2024). However, the pronounced decline observed in France after 1870 is largely attributed to economic forces driven by technological acceleration.

[20] The impact of rising returns to human capital on fertility decline during the demographic transition is a foundational element of Unified Growth Theory. Evidence from a diverse range of countries supports the existence of the quantity-quality trade-off mechanism during these historical periods. Studies from the United States (Bleakly and Lange, 2009; Ager and Cinnirella, 2020), Germany (Becker et al., 2010), France (Murphy, 2015; Bignon and García-Peñalosa, 2021), Ireland (Fernihough, 2017), China (Shiue, 2017), England (Klemp and Weisdorf, 2019), and Nigeria (Okoye and Pongou, 2024) provide corroborative evidence. Additionally, cross-country analyses further substantiate the

This significant decline in fertility freed the development process from the counterbalancing pressures of population growth, allowing technological advancements to generate enduring prosperity rather than temporary gains.[21] With an increasingly skilled workforce and greater investment in human capital, technological progress further accelerated, enhancing human prosperity and delivering sustained growth in per capita income.

The past two centuries have been revolutionary, with human prosperity advancing at an unprecedented rate by nearly every conceivable measure. Global average per capita income has increased fourteen-fold and life expectancy has more than doubled. The harsh world, once plagued by high child mortality, has given way to a prosperous era in which the loss of a child is a profound tragedy. Much like the spread of the Neolithic Revolution millennia earlier, which radiated from initial centers such as the Fertile Crescent and the Yangtze River, the Industrial Revolution and the demographic transition began in Western Europe and gradually spread across much of the globe over the course of the twentieth century, enhancing prosperity wherever they took hold.

However, just as some water molecules in a kettle transition to a gaseous state before others, humanity's phase transition unfolded at different times across the globe, creating previously unimaginable levels of inequality between the countries that underwent this transformation early and those that remained trapped in stagnation for longer.

The advancement of the quality of life has neither been universal nor inevitable. Long-standing institutional, cultural, geographical, and societal characteristics, along with the impact of colonialism, have contributed to the varying pace of the transition from stagnation to growth, leading to significant disparities in living standards. Institutional reforms, occurring at critical junctures, have occasionally steered countries onto divergent paths, deepening these inequalities over time (North, 1990; and Acemoglu and Robinson, 2012). In a similar vein, the uneven spread

impact of technological acceleration in the quantity-quality trade-off (Galor and Mountford, 2008; Vogl, 2016; and Madsen and Strulik, 2023).

[21] The pivotal role of the fertility decline in shaping subsequent growth processes and comparative development is underscored by quantitative analysis (Cervellati and Sunde, 2015) and supported by a time-series study of 21 developed economies spanning 1820–2015 (Madsen et al., 2020).

of growth-enhancing cultural norms has contributed to the varied trajectory of human progress (Guiso et al., 2006; Tabellini, 2010; and Spolaore and Wacziarg, 2013). Yet deeper factors, rooted in the distant past, often underpinned the emergence of cultural norms, political institutions and technological shifts, shaping the ability of societies to flourish and prosper.

Geographical factors, such as fertile soil and favorable climatic conditions, promoted the emergence of growth-enhancing institutional cultural and linguistic traits, including a future-oriented mindset, gender equality, social cooperation, and their associated linguistic traits, as well as effective state capacity.[22] In contrast, regions suited for large-scale plantations often gave rise to extractive, growth-retarding political and educational institutions (Engerman and Sokoloff, 1997; and Galor et al., 2009). Biodiversity, which promoted the transition to sedentary agricultural communities, influenced the timing of the onset of the Neolithic Revolution and contributed to development during the pre-industrial era (Diamond, 1997). Nevertheless, these beneficial effects dissipated as societies shifted to the modern globalized era in which comparative advantage in agriculture resulted in limited technological spillover (Galor, 2022). Lastly, population diversity within societies has had a lasting impact on economic prosperity and the degree of inequality within and across societies. Moderate diversity has been conducive for prosperity, balancing the benefits of diversity for cross-fertilization and innovation with its challenges to social cohesion (Ashraf and Galor, 2013).[23]

5. From Population Explosion to Population Collapse

The surge in income per capita over the past two centuries ignited an unprecedented rise in world population, sparking fears in the early twentieth century of an impending catastrophe, as food supplies seemed inadequate to sustain the rapidly growing population (Ehrlich, 1968). Yet, a marked transformation in demographic trends has shifted humanity's concerns. As fertility rates in more than half of the world's nations have fallen beneath the replacement level, fears have ironically pivoted toward concerns over population collapse and societal breakdown.

[22] See respectively (Galor and Özak (2016); Boserup (1970); Alesina et al. (2013); Talhelm et al. (2014); Galor et al. (2025); and Mayshar et al. (2022).
[23] See also: Arbatlı et al. (2020); Ashraf et al. (2021); and Galor et al. (2023, 2024).

Unified Growth Theory suggests that the pattern of rising fertility rates in the initial growth phase, followed by a sharp decline during the demographic transition, is an inherent characteristic of the growth process. Furthermore, the theory posits that fertility rates could fall to levels permanently below replacement, paving the way for a long-term trajectory of population decline.

Yet, this trend of a shrinking workforce and an increasing old-age dependency ratio does not necessarily signal societal collapse. As Unified Growth Theory highlights, a decline in fertility could significantly boost productivity through: (i) reduced dilution of resources and infrastructure across a growing population; (ii) increased parental investment in children's education; (iii) higher female labor force participation; and (iv) higher incentives for the adoption of productivity-enhancing AI technologies. Although the old-age dependency ratio is expected to rise due to declining fertility and rising life expectancy, the productivity-adjusted dependency ratio could plausibly decline, as the working-age population becomes better educated, possesses greater resources, and benefits from AI technologies. Moreover, as AI-driven health advancements enable older individuals to remain productive beyond traditional retirement ages, the pressure on the shrinking workforce may be further alleviated.

Most significantly, just as fears of societal collapse may be overdrawn, so too are concerns about a declining population hindering technological progress. The transformative potential of AI is poised to accelerate innovation, even amid a shrinking population. While declining fertility rates pose moral, philosophical, and economic challenges, they also create profound opportunities to sustain productivity growth, elevate living standards globally, and reduce humanity's collective adverse footprint on the planet.

6. Concluding Remarks

The journey of humanity since the emergence of Homo sapiens in Africa nearly 300,000 years ago is abundant with captivating episodes. It is easy to drift in this ocean of details, buffeted by the waves and unaware of the mighty currents underneath. Unified Growth Theory reveals these deeper currents: the interplay between technological progress and the size and the composition of

the population. Understanding the history of humankind would be hindered without recognizing the contributions of these forces to the progression of the human species—the evolution of the human brain, the Neolithic and Industrial Revolutions, the growth of human capital, the demographic transition, the take-off from stagnation to growth, and the divergence in the wealth of nations. This unified framework provides a clear axis for decoding the journey of humanity, the roots of growth and inequality, and the future trajectory of the human species. In its absence, the history of human development would be reduced to a mere chronology of events—an incomprehensible wilderness of rising and falling civilizations.

References

Acemoglu, Daron, and James A. Robinson, *Why Nations Fail: The origins of power, prosperity, and poverty*, Crown Books, 2012.

Ager, Philipp, and Francesco Cinnirella. "Froebel's Gifts: How the Kindergarten Movement Changed the American Family." (2020).

Aghion, Phillipe, and Peter Howitt, "A Model of Growth Through Creative Destruction", *Econometrica* 60, no. 2 (1992): 323–51.

Akbari, Ali, Alison R. Barton, Steven Gazal, Zheng Li, Mohammadreza Kariminejad, Annabel Perry, Yating Zenn, … & Reich, David. "Pervasive findings of directional selection realize the promise of ancient DNA to elucidate human adaptation." bioRxiv (2024).

Alsan, Marcella, "The effect of the tsetse fly on African development", American Economic Review 105, no. 1 (2015): 382–410.

Andersen, Thomas Barnebeck, Carl-Johan Dalgaard and Pablo Selaya, "Climate and the Emergence of Global Income Differences," *The Review of Economic Studies* 83, no. 4 (2016): 1334–63.

(2019): 397–425.

Arbatlı, Cemal Eren, Quamrul H. Ashraf, Oded Galor, and Marc Klemp. "Diversity and conflict." *Econometrica* 88, no. 2 (2020): 727-797.

Ashraf, Quamrul, and Oded Galor, "The 'Out of Africa' hypothesis, human genetic diversity, and comparative economic development", *American Economic Review* 103, no. 1 (2013): 1–46.

Ashraf, Quamrul, and Oded Galor, "Dynamics and stagnation in the Malthusian Epoch," *American Economic Review* 101, no. 5 (2011): 2003–41.

Ashraf, Quamrul, Oded Galor and Marc Klemp, 'Ancient Origins of the Wealth of Nations', in *Handbook of Historical Economics*, Elsevier, 2021.

Attar, M. Aykut. "Technology and survival in preindustrial England: A Malthusian view: A Malthusian view". Journal of Population Economics 36, no. 4 (2023): 2071-2110.

Barlow, Nora, ed., *The Autobiography of Charles Darwin 1809–1882*, Collins, 1958.

Becker, Sascha O., Erik Hornung, and Ludger Woessmann. "Education and catch-up in the industrial revolution," *American Economic Journal: Macroeconomics* 3, no. 3 (2011): 92-126.

Becker, Sascha O., Francesco Cinnirella and Ludger Woessmann, 'The Trade-Off Between Fertility and Education: Evidence from Before the Demographic Transition', Journal of Economic Growth 15, no. 3 (2010): 177–204.

Bignon, Vincent, and Cecilia García-Peñalosa, '"The toll of tariffs: Protectionism, education and fertility in late 19th century France." (2021).

Bisin, Alberto, and Thierry Verdier, 'The economics of cultural transmission and the dynamics of preferences', *Journal of Economic Theory* 97, no. 2 (2001): 298–319.

Blanc, Guillaume. " The Cultural Origins of the Demographic Transition in France." (2024).

Bleakley, Hoyt, and Fabian Lange, 'Chronic Disease Burden and the Interaction of Education, Fertility, and Growth', *Review of Economics and Statistics* 91, no. 1 (2009): 52–65.

Bolt, Jutta, Robert Inklaar, Herman de Jong and Jan Luiten van Zanden, 'Rebasing 'Maddison': new income comparisons and the shape of long-run economic development', Maddison Project Database (2018).

Bolt, Jutta, and Jan Luiten van Zanden, 'The Maddison Project: collaborative research on historical national accounts', *The Economic History Review* 67, no. 3 (2014): 627–51, Maddison Project Database (version 2013).

Boserup, Ester, *Woman's Role in Economic Development*, St. Martin's Press, 1970.

Boserup, Ester, *The Conditions of Agricultural Growth: The economics of agrarian change under population pressure*, Aldine Publishing, 1965.

Boucekkine, Raouf, David De la Croix, and Dominique Peeters. "Early literacy achievements, population density, and the transition to modern growth." *Journal of the European Economic Association* 5, no. 1 (2007): 183-226.

Cervellati, Matteo, Gerrit Meyerheim, and Uwe Sunde. "The empirics of economic growth over time and across nations: a unified growth perspective." *Journal of Economic Growth* 28, no. 2 (2023): 173-224.

Cervellati, Matteo, and Uwe Sunde. "The economic and demographic transition, mortality, and comparative development." *American Economic Journal: Macroeconomics*7, no. 3 (2015): 189-225.

Cervellati, Matteo, and Uwe Sunde, 'Human capital formation, life expectancy, and the process of development', *American Economic Review* 95, no. 5 (2005): 1653–72.

Chaney, Eric, and Richard Hornbeck. "Economic dynamics in the Malthusian era: evidence from the 1609 Spanish expulsion of the Moriscos." *The Economic Journal* 126, no. 594 (2016): 1404-1440.

Charnov, Eric L., and S. K. Morgan Ernest, 'The offspring-size/clutch-size trade-off in mammals', *The American Naturalist* 167, no. 4 (2006): 578–82.

Chen, Shuo, and James Kai-sing Kung, 'Of Maize and Men: The Effect of a New World Crop on Population and Economic Growth in China', *Journal of Economic Growth* 21, no. 1 (2016): 71–99.

Collins, Jason, Boris Baer, and Ernst Juerg Weber. "Economic Growth and Evolution: Parental Preference for Quality and Quantity of Offspring." *Macroeconomic Dynamics* 18, no. 8 (2014): 1773-1796.

Crafts, Nicholas F. R., and C. Knick Harley, 'Output Growth and the British Industrial Revolution: A Restatement of the Crafts–Harley view', *The Economic History Review* 45, no. 4 (1992): 703–30.

Dalgaard, Carl-Johan, and Holger Strulik. "The physiological foundations of the wealth of nations." *Journal of Economic Growth* 20 (2015): 37-73.

de La Croix, David, Eric B. Schneider and Jacob Weisdorf, 'Childlessness, celibacy and net fertility in pre-industrial England: the middle-class evolutionary advantage', *Journal of Economic Growth* 24, no. 3 (2019): 223–56.

de la Croix, David, and Omar Licandro. "The child is father of the man: Implications for the demographic transition." *The Economic Journal* 123, no. 567 (2013): 236-261.

De Pleijt, Alexandra, Alessandro Nuvolari and Jacob Weisdorf, 'Human capital formation during the first industrial revolution: Evidence from the use of steam engines', *Journal of the European Economic Association* 18, no. 2 (2020): 829–89.

Diamond, Jared, *Guns, Germs and Steel: The Fates of Human Societies*, Vintage, 1997.

Doepke, Matthias, and Fabrizio Zilibotti, 'Occupational choice and the spirit of capitalism', *The Quarterly Journal of Economics* 123, no. 2 (2008): 747–93.

Doepke, Matthias. "Accounting for fertility decline during the transition to growth." *Journal of Economic Growth* 9 (2004): 347-383.

Ehrlich, Paul R. (1968). *The Population Bomb*. New York: Ballantine Books.

Ekanayake, P. Niluka SP, Jakob B. Madsen, and Tushar Bharati. "Trade and economic growth: Does the sophistication of traded goods matter?." *Journal of Economic Growth* 28, no. 4 (2023): 481-524.

Engerman, Stanley, and Kenneth Sokoloff, 'Factor Endowments, Institutions, and Differential Paths of Growth Among New World Economies: A View from Economic Historians of the United States', in *How Latin America Fell Behind: Essays on the Economic Histories of Brazil and Mexico, 1800-1914*, edited by Stephen Haber, 260–304, Stanford University Press, 1997.

Fernandez-Villaverde, Jesus. "Was Malthus Right? Economic growth and population dynamics." (2001).

Fernihough, A., 'Human Capital and the Quantity–Quality Trade-Off During the Demographic Transition', *Journal of Economic Growth* 22 no. 1 (2017): 35–65.

Fernihough, Alan. "Malthusian dynamics in a diverging Europe: Northern Italy, 1650–1881." *Demography* 50, no. 1 (2013): 311-332.

Foster, Andrew D., and Mark R. Rosenzweig. "Technical change and human-capital returns and investments: evidence from the green revolution." The American Economic Review (1996): 931-953.

Franck, Raphaël, and Oded Galor, 'Flowers of Evil or Evil of Flowers? Industrialization and Long-Run Development', *Journal of Monetary Economics* 117 (2021): 108-128.

Franck, Raphaël, and Oded Galor, 'Technology-skill Complementarity in Early Phases of Industrialization', *The Economic Journal* 132, no. 642 (2022): 294-325.

Gallup, John Luke, Jeffrey D. Sachs and Andrew D. Mellinger, 'Geography and economic development', *International Regional Science Review* 22, no. 2 (1999): 179–232.

Galor, Oded, *The Journey of Humanity: Origins of Wealth and Inequality*, Penguin, 2022.

Galor, Oded, *Unified Growth Theory*, Princeton University Press, 2011.

Galor, Oded, *Discrete Dynamical Systems*, Springer, 2010.

Galor, Oded, 'The Lawrence R. Klein lecture – Comparative economic development: Insights from unified growth theory', *International Economic Review* 51, no. 1 (2010): 1–44.

Galor, Oded, 'From Stagnation to Growth: Unified Growth Theory', *Handbook of Economic Growth* 1 (2005): 171–293.

Galor, Oded, 'Convergence? Inferences from theoretical models', *The Economic Journal* 106, no. 437 (1996): 1056–69.

Galor, Oded, and Marc Klemp, 'Human Genealogy Reveals a Selective Advantage to Moderate Fecundity', *Nature Ecology & Evolution* 3, no. 5 (2019): 853–7.

Galor, Oded, Marc Klemp, and Daniel C. Wainstock. *Roots of Inequality*. Working Paper w31580. National Bureau of Economic Research (2023).

Galor, Oded, Marc Klemp, and Daniel C. Wainstock. *Roots of Cultural Diversity*. CEPR Discussion Paper No. 19718. CEPR Press, Paris & London (2024). https://cepr.org/publications/dp19718

Galor, Oded, and Andrew Mountford, 'Trading Population for Productivity: Theory and evidence', *The Review of Economic Studies* 75, no. 4 (2008): 1143–79.

Galor, Oded, and Andrew Mountford, 'Trade and the great divergence: the family connection', *American Economic Review* 96, no. 2 (2006): 299–303.

Galor, Oded, and Omer Moav, 'Das Human-Kapital: A theory of the demise of the class structure', *The Review of Economic Studies* 73, no. 1 (2006): 85–117.

Galor, Oded, and Omer Moav. "From physical to human capital accumulation: Inequality and the process of development." *The Review of Economic Studies* 71, no. 4 (2004): 1001-1026.

Galor, Oded, and Omer Moav, 'Natural Selection and the Origin of Economic Growth', *The Quarterly Journal of Economics* 117, no. 4 (2002): 1133–91.

Galor, Oded, and Omer Moav, 'Ability-biased technological transition, wage inequality, and economic growth', *The Quarterly Journal of Economics* 115, no. 2 (2000): 469–97.

Galor, Oded, Omer Moav and Dietrich Vollrath, 'Inequality in Landownership, the Emergence of Human-Capital Promoting Institutions, and the Great Divergence', *The Review of Economic Studies* 76, no. 1 (2009): 143–79.

Galor, Oded, and Stelios Michalopoulos, 'Evolution and the Growth Process: Natural selection of entrepreneurial traits', *Journal of Economic Theory* 147, no. 2 (2012): 759–80.

Galor, Oded, and Ömer Özak, 'The Agricultural Origins of Time Preference', *American Economic Review* 106, no. 10 (2016): 3064–103.

Galor, Oded, and Ömer Özak, 'Roots of Cultural and Linguistic Traits,' *The Economic Journal* (2025).

Galor, Oded, and Daniel Tsiddon, 'Technological progress, mobility, and economic growth', *American Economic Review* (1997): 363–82.

Galor, Oded, and David N. Weil, 'Population, Technology, and Growth: From Malthusian Stagnation to the Demographic Transition and Beyond', American Economic Review 90, no. 4 (2000): 806–28.

Galor, Oded, and David N. Weil. "From Malthusian stagnation to modern growth." American Economic Review 89, no. 2 (1999): 150-154.

Galor Oded, and David N. Weil. 'The Gender Gap, Fertility, and Growth,' American Economic Review 86, no. 3 (1996): 374–87.

Galor, Oded, and Joseph Zeira. "Income distribution and macroeconomics." The Review of Economic Studies 60, no. 1 (1993): 35-52.

Grossman, Gene M., and Elhanan Helpman, Innovation and Growth in the Global Economy, MIT Press, 1991.

Guiso, Luigi, Paola Sapienza and Luigi Zingales, 'Does Culture Affect Economic Outcomes?', Journal of Economic Perspectives 20, no. 2 (2006): 23–48.

Hassler, John, and Jose V. Rodriguez Mora. "Intelligence, social mobility, and growth." *American Economic Review* 90, no. 4 (2000): 888-908.

Hansen, Gary D., and Edward C. Prescott. "Malthus to Solow." *American economic review* 92, no. 4 (2002): 1205-1217.

Hazan, Moshe, and Binyamin Berdugo, 'Child Labour, fertility, and Economic Growth', *The Economic Journal* 112, no. 482 (2002): 810–28.

Hobbes, Thomas, *Leviathan, or, The Matter, Form, and Power of a Common-Wealth Ecclesiastical and Civil*, printed for Andrew Crooke, 1651.

Klemp, Marc P., 'Prices, Wages and Fertility in Pre-Industrial England', *Cliometrica* 6, no. 1 (2012): 63–77.

Klemp, Mark, and Jacob L. Weisdorf, 'Fecundity, Fertility and the Formation of Human Capital', *The Economic Journal* 129, no. 618 (2019): 925–60.

Klemp, Marc, and Niels Framroze Møller. "Post-Malthusian Dynamics in Pre-Industrial Scandinavia." The *Scandinavian Journal of Economics* 118, no. 4 (2016): 841-867.

Kremer, Michael, 'Population growth and technological change: One million BC to 1990', *The Quarterly Journal of Economics* 108, no. 3 (1993): 681–716.

Kuhn, Thomas S., *The Copernican Revolution: Planetary Astronomy in the Development of Western Thought*, Vol. 16, Harvard University Press, 1957.

Lagerlöf, Nils-Petter. "Understanding Per-Capita Income Growth in Preindustrial Europe." *International Economic Review* 60, no. 1 (2019): 219-240.

Lagerlöf, Nils-Petter. "Malthus in Sweden." *The Scandinavian Journal of Economics* 117, no. 4 (2015): 1091-1133.

Lagerlöf, Nils-Petter, 'The Galor–Weil model revisited: A quantitative exercise', *Review of Economic Dynamics* 9, no. 1 (2006): 116–42.

Lagerlöf, Nils-Petter, "From Malthus to modern growth: the three regimes revisited." *International Economic Review* 44, no. 2 (2003): 755-777.

Lucas, Robert E. *Lectures on economic growth*. Harvard University Press, 2002.

Lucas Jr, Robert E. "On the mechanics of economic development." *Journal of monetary economics* 22, no. 1 (1988): 3-42.

MacArthur, Robert H., and Edward O. Wilson, The Theory of Island Biogeography, Vol. 1, Princeton University Press, 1970.

Madsen, Jakob, and Holger Strulik. "Testing unified growth theory: Technological progress and the child quantity-quality tradeoff." *Quantitative Economics* 14, no. 1 (2023): 235-275.

Madsen, Jakob B., Md Rabiul Islam, and Xueli Tang. "Was the post-1870 fertility transition a key contributor to growth in the West in the twentieth century?" *Journal of Economic Growth* 25 (2020): 431-454.

Madsen, Jakob B., Peter E. Robertson, and Longfeng Ye. "Malthus was right: Explaining a millennium of stagnation." *European Economic Review* 118 (2019): 51-68.

Madsen, Jakob B., and Fabrice Murtin. "British economic growth since 1270: the role of education." *Journal of Economic Growth* 22 (2017): 229-272.

Madsen, Jakob B., James B. Ang, and Rajabrata Banerjee. "Four centuries of British economic growth: the roles of technology and population." *Journal of Economic Growth* 15 (2010): 263-290.

Malthus, Thomas R. 1798. An Essay on the Principle of Population. Reprint, ed. Geoffrey Gilbert, 1999. Oxford: Oxford University Press.

Mayshar, Joram, Omer Moav, and Luigi Pascali. "The Origin of the State: Land productivity or Appropriability?." Journal of Political Economy 130, no. 4 (2022): 1091-1144.

Møller, Niels Framroze, and Paul Sharp, 'Malthus in cointegration space: evidence of a post-Malthusian pre-industrial England', Journal of Economic Growth 19, no. 1 (2014): 105–40.

Murphy, T. E., 'Old Habits Die Hard (Sometimes)', Journal of Economic Growth 20, no. 2 (2015): 177–222.

North, Douglass, Institutions, Institutional Change, and Economic Performance, Cambridge University Press, 1990.

Okoye, Dozie, and Roland Pongou. "Missions, fertility transition, and the reversal of fortunes: evidence from border discontinuities in the emirates of Nigeria." Journal of Economic Growth 29, no. 2 (2024): 251-325.

Parente, Stephen L., and Edward C. Prescott. "A unified theory of the evolution of international income levels." In *Handbook of economic growth*, vol. 1, pp. 1371-1416. Elsevier, 2005.

Pfister, Ulrich, and Georg Fertig. "From Malthusian disequilibrium to the post-Malthusian era: The evolution of the preventive and positive checks in Germany, 1730–1870." Demography 57, no. 3 (2020): 1145-1170.

Popper, Karl, The Open Society and Its Enemies, Routledge, 1945.

Romer, Paul M., 'Endogenous Technological Change', Journal of Political Economy 98, no. 5, Part 2 (1990): S71–102.

Schultz, Theodore W. "The value of the ability to deal with disequilibria." Journal of economic literature 13, no. 3 (1975): 827-846.

Shiue, Carol H., 'Human Capital and Fertility in Chinese Clans Before Modern Growth', Journal of Economic Growth 22, no. 4 (2017): 351–96.

Simon, Julian Lincoln, The Economics of Population Growth, Princeton University Press, 1977.

Solow, Robert M. "A contribution to the theory of economic growth." The quarterly journal of economics 70, no. 1 (1956): 65-94.

Spolaore, Enrico, and Romain Wacziarg. "Fertility and modernity." *The Economic Journal* 132, no. 642 (2022): 796-833.

Spolaore, Enrico, and Romain Wacziarg, 'How Deep are the Roots of Economic Development?', Journal of Economic Literature 51, no. 2 (2013): 325–69.

Squicciarini, Mara P., and Nico Voigtländer, 'Human Capital and Industrialization: Evidence from the Age of Enlightenment', The Quarterly Journal of Economics 130, no. 4 (2015): 1825–83.

Tabellini, Guido. "Culture and institutions: economic development in the regions of Europe." *Journal of the European Economic association* 8, no. 4 (2010): 677-716.

Talhelm, Thomas, Xiao Zhang, Shige Oishi, Chen Shimin, Dechao Duan, Xiaoli Lan and Shinobu Kitayama, 'Large-scale psychological differences within China explained by rice versus wheat agriculture', Science 344, no. 6184 (2014): 603–8.

Vogl, Tom S., 'Differential fertility, human capital, and development', The Review of Economic Studies 83, no. 1 (2016): 365–401.

Voigtländer, Nico, and Hans-Joachim Voth, 'Why England? Demographic Factors, Structural Change and Physical Capital Accumulation During the Industrial Revolution', Journal of Economic Growth 11, no. 4 (2006): 319–61.

Walker, Robert S., Michael Gurven, Oskar Burger and Marcus J. Hamilton, 'The trade-off between number and size of offspring in humans and other primates', Proceedings of the Royal Society B: Biological Sciences 275, no. 1636 (2008): 827–34.