Unified Growth Theory: A Critical Methodological and Theoretical Analysis with Insights from Multiple Fields of Research

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Abstract

This paper seeks to bring to light some of the controversies related to Unified Growth Theory (UGT), Oded Galor's seminal work on the origin of economic growth. Discussing the different theories present in several fields related to UGT, such as fertility limitations related to population and the Great Divergence, leads to varying implications and points of view depending on the field of research. Further, direct controversies related to the methodology and theory in UGT are discussed and explored. Controversies surrounding the related literature are also explored, namely the "Out of Africa" Hypothesis (2013). Lastly, the impact of UGT on Growth Economics as a whole is briefly studied. Upcoming research could benefit from studying the presented interactions among different fields of study, while also diving into related controversies on the topic.

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1. Introduction

“The inconsistency of exogenous and endogenous growth models with some of the most fundamental features of process of development, has led recently to a search for a unified theory that would unveil the underlying micro-foundations of the growth process in its entirety, capturing the epoch of Malthusian Stagnation that characterized most of human history, the contemporary era of modern economic growth, and the underlying driving forces that triggered the recent transition between these regimes and the associated phenomenon of the Great Divergence in income per capita across countries.”

— Galor, (2005). From Stagnation to Growth: The Unified Growth Theory.

Unified Growth Theory (UGT) has been at the forefront of debate since its inception in 2005. It seeks to capture the unification of the entire process of development and all its fundamental forces since the beginning of recorded history, hence the name. It rose to prominence due to the many shortcomings of endogenous growth theories (Sachs and Warner, 1997), but it was mainly the inability of endogenous growth theories to explain the phenomenon of convergence — the hypothesis that the per capita incomes of poorer economies will grow faster than richer economies. However, the different hypotheses on convergence make for a messy debate. Galor (1996) discusses the different types of convergence. Absolute convergence disregards initial conditions, stating that all countries’ per capita incomes will converge in the long run. Conditional convergence implies that countries with similar structural characteristics converge independently of their initial conditions. The last hypothesis which is most in line with Unified Growth Theory is club convergence — countries that are structurally identical and that have similar initial conditions will have their per capita incomes converge in the long run.

After settling on club convergence as the hypothesis of choice, Unified Growth Theory took on the challenge of attempting to explain the growth process over the entirety of recorded history, from the first Agricultural Revolution [1] to the Modern Growth Regime [2]. The theory suggests that technological progress was counteracted by population growth, but the rapidness of technological progress increased due to a reinforced interaction with the size and composition of a given population. This allowed for more resources to be spent on education which triggered a decline in fertility, leading to an increase in income per capita as opposed to an increase in population, leading to the period of sustained economic growth we have today.

The overarching framework of Unified Growth Theory, as illustrated in the previous paragraph, touches on many different economic, sociological, geographical, anthropological and demographic issues, answering questions and discussing ideas that exist in each of the fields. For instance, the interaction between technology and a population is a sociological issue. The size and composition of a population is a demographic issue. Spending more resources on education is an economic, or even cultural, issue. A decline in fertility is an anthropological issue. Where each transition happened is a geographical issue.

However, it is not the issues at face value that is the talking point here — the perspectives each discipline has on their respective issues are sources of controversy. For example, an economist would view the interaction between technology and population as a tool to study the effects on production and growth, while a sociologist would use the very same interaction in order to study

[1] The Agrarian Revolution was the extensive transition from hunter gatherer communities to ones where agriculture and settlement dominated, which allowed for more rapid increases in population.

[2] The Modern Growth Regime is the pattern of growth we experience today.

the impact of technology on society. Because the disciplines do not see eye to eye, assumptions made to explain either perspective might overlap or contradict assumptions made by the other, leading to a source of controversy.

Due to the importance of the theory in our comprehension of how economic growth developed, I feel it deserves a critical analysis in order to understand the limitations and controversies that arise related to Unified Growth Theory. Therefore, I explore the following question throughout this paper:

What are the methodological, philosophical and theoretical reasons behind the controversies surrounding unified growth theory from a behavioural economic, mathematical, and anthropological perspective during the transition period from the Malthusian epoch to the Modern Growth Regime?

As with all theories, this one certainly has its limitations. As a unified growth theory, it should be able to explain the Great Divergence[3]. This directly combats the theory of convergence as well. Although the Unified Growth Theory certainly does not explain the Great Divergence, it suggests that "differences in the timing of the take-off from stagnation to growth across countries contributed significantly to the Great Divergence and to the emergence of convergence clubs." (Galor, 2005). In light of the aforementioned quote, issues arise regarding the Great Divergence; mainly when, where, and why.

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[3] The Great Divergence is the socioeconomic shift from pre-modern constraints on growth and population traps to the modern growth regime that only happened in specific parts of the world. Some growth constraints include rapid depletion of physical capital and a lack of investment in human capital. Population traps are conditions where food shortages would prevent excess population from growing.

The next section will discuss the origins and causes of the Great Divergence. Then, the discussion will shift towards fertility limitations with regards to population and biology. The section after that is about the methodological and theoretical controversies that surround Unified Growth Theory from a plethora of perspectives due to different methodological and theoretical preferences in each field. Chapter 5 provides a look at some related controversies to UGT, namely the “Out of Africa” Hypothesis. The penultimate chapter takes a look at the impact UGT has had in the growth economics literature. The final section presents limitations in this research, concluding remarks, and recommendations for future research.

2. The Great Divergence

2.1 The Origin of the Great Divergence

The origin of the Great Divergence has been a source of controversy for decades. Both the timing and the causes of the phenomenon are disputed. Depending on the school, the Great Divergence could have started at any time between the fifteenth and the nineteenth century. Galor (2005) generally uses 1820 as the starting point. Other researchers, such as Dutta et al. (2017) state that “The Great Divergence refers to the worldwide growth in the late Medieval period after Columbus and preceding the Industrial Revolution”, not mentioning a concrete date. However, there has been evidence provided by Maddison (2001) showing a large difference in income per capita across different regions of the world as early as 1000 AD. He estimates that between the years 1000 and 1500, per capita income in Western Europe almost doubled, while China’s per capita income increased by a third, other parts of Asia experienced even less growth, and Africa regressed during that time period. This means that there was already disparity among different parts of the world when it came to income per capita in the era of Malthusian Stagnation. Despite this, it is widely accepted that the Great Divergence occurred during the industrial revolution in the 19th century. Furthermore, the very existence of the Great Divergence has also been disputed. Some controversies related to the Great Divergence will be discussed in Section 4.1.

2.2 Causes of the Great Divergence

There are many theories surrounding the cause, or causes, of the Great Divergence. While researchers in some disciplines completely write off the idea, others consider it a concrete basis for research, taking it as given. One cause of the Great Divergence is forwarded by Dutta et al. (2017). They present evidence that improvements in agriculture in China allowed it to pull forward in agriculture, leading to a larger population but lower living standards. However, this hindered its ability to compete with Europe when it came to GDP per capita. A tradeoff is demonstrated between the “bread” sector (agriculture) and the “circus” sector (industry), where an increase in food supply increased population but decreased living standards as there was no progress on the technological front. Moreover, their model implies that improvements in the circus sector caused by technological enhancements largely increases GDP per capita in the long run. The ratio of industry to agriculture determined living standards several centuries ago and still does today. However, an important role in the Great Divergence was the introduction of maize between 1500 and 1900 in China (Dutta et al., 2017). This is similar to the introduction of potatoes in Ireland, greatly increasing the amount of people that could be fed, setting Ireland and China on similar trajectories — improvements in bread technology increased GDP, increased population, but decreased income per capita.

Another cause of the Great Divergence is the location of coal deposits and the discovery of the New World (Pomeranz, 2000). He argues that despite the parallels in life expectancy, consumption and markets, Europe’s divergence in the 1800 was catalyzed by the location of coal and the discovery of the New World. Since the Old World (Europe, Africa and Asia) faced shortages in the 1700s when it came to land-intensive products, substituting wood for coal meant that Europe could focus on energy-intensive sectors, and using land less efficiently due to geographical factors became less of a problem. Furthermore, trips to the New World meant that more products entered Europe as a result of trade, which in turn allowed Europe to focus on resource-intensive activities as opposed to labour-intensive ones. This meant that Europe was able to produce more goods, whereas China was not, leading to the Great Divergence.

Inequality in land ownership was another cause of the Great Divergence (Galor et al., 2009). The emergence of institutions that promote human capital, such as child labour laws and public schooling, was negatively affected by the existence of land inequality. Land-abundant countries, such as China, were characterized by unequal land distribution, whereas land-scarce countries, such as those in Europe, had a more equal distribution of land[4]. This meant a few things. First, the elites profiting from land-intensive activities favoured policies that hindered the ability of the masses to receive education, whereas those that profited from sectors that relied on high levels of human capital induced by industrialization supported policies that encouraged education. Due to the nature of Europe's land distribution, human capital was higher in demand than physical capital while industrialization was taking place. Furthermore, "a rise in the level of education increased the productivity of labour in industrial production more than in agriculture, decreasing the return to land due to labour migration and the associated rise in wages" (Galor et al., 2009, p. 2). This led to the conclusion that as long as landowners could affect the political process, human capital accumulation would suffer due to the slowdown of the industrialization process.

[4] In land abundant countries, land owners had a larger share of the land since the size of farmland was larger, and more importantly they had more sophisticated agricultural technology, allowing for fewer workers needed to tend to larger pieces of land.

As mentioned earlier, some parts of the world (namely China) had an increase in population numbers with low living standards due to advances in agriculture. On the other side of the coin, some areas experienced limitations in fertility, keeping living standards at relatively respectable levels. Thus, the origins and impacts of these limitations are of interest as well.

3. Fertility and Biology

3.1 Fertility

The origin of historical fertility limitations has been a source of debate for many years, but its impact on population is evident. Voigtlander and Voth (2013) argue that fertility restriction was “invented” by the West around the fourteenth century. They discuss the impact of the European Marriage Pattern (EMP) on childbirth level as the first socio-economic institution in history that limited fertility. The EMP is a demographic system where women marry after 24 years of age (considered late), where 10-15% of people never marry (considered a high proportion), and nuclear families make up more than 80% of all families (considered predominant) (Dennison and Ogilvie, 2004).

The EMP reduced childbirth by around one third between the fourteenth and eighteenth centuries as it only became prevalent after the Black Death in 1350. The reason it became so prevalent was because between a third and half of the population of Europe died due to the deadly plague, which decreased the ratio of labour to land because there was less people in general, favouring raising animals as livestock, ie. animal husbandry, as it is a land-intensive sector. More women began working in animal husbandry because of a comparative advantage they had to men working in plow agriculture (Alesina, Giuliano, and Nunn, 2011), which saw an improvement in their employment opportunities. However, most labour contracts required labour to be done all year long, and women had to remain celibate and unmarried — the alternative was termination of the contract. Marriage ages increased, and fertility levels decreased.

However, there is a difference between fertility limitations and the causes of so-called “fertility transitions”. A fertility transition is the process by which fertility and mortality fall from high or medium equilibrium levels to lower ones in given populations, whereas fertility limitations are usually imposed by social rules and laws that artificially limit fertility; the previous paragraph was an example of fertility limitations because labour contracts fall under social rules. England’s first fertility transition fell between 1760 and 1800 (Clark and Cummins, 2015), coinciding with both the start of the transition period from the Malthusian Epoch to the Modern Growth Regime and the Industrial Revolution in England. Clark and Cummins claim that “despite many years of research into the demography of pre-industrial England, we seem to have missed an earlier substantial transformation in the demographic system that accompanied the Industrial Revolution” (2010, p. 2). This falls in line with the rise to prominence of the European Marriage Pattern a few centuries earlier due to the Black Death, but contradicts Clark and Cummins’ work — they state that only in the late nineteenth century was there a sign of a decline in net fertility. This raises the issue of whether fertility decline happened due to the EMP between the fourteenth and eighteenth centuries (from the era of Malthusian stagnation to the transition period) or because of the quantity-quality tradeoff when it came to raising offspring during the demographic transition.

The quantity-quality tradeoff has independent origins in both economics and evolutionary ecology. Gary Becker is usually credited as the first economist to study fertility, as before that it was generally considered to be outside the realm of the analysis of economics (Lawson and Mulder, 2016). However, when Becker brought the subject to economic eyes, he formalized the notion that utility is derived from offspring quality and quantity by parents. Furthermore, he stated that lower fertility at greater wealth meant that there was more human capital investment and the cost per child was higher (Becker and Lewis, 1973). On the other hand, evolutionary ecology states that since resources are finite across all species, there are plenty of decisions that lead to tradeoffs, such as placing a higher weight on survival instead of reproduction, investing in mating as opposed to parenting, and whether the quality or quantity of offspring is a priority. Natural selection is the tool used to optimize these tradeoffs, and although the concepts of opportunity cost and scarcity are inherently economic, evolutionary life-history theorists put a different spin on the application of these various terms as they work under the assumption that fitness is the ultimate utility function. As a result, individual organisms forgo their well-being and the well-being of any of their children as long as reproduction maximizes fitness (Lawson and Mulder, 2016). The quantity-quality debate is discussed in detail in section 4.3.

Since the Black Death killed between a third and half of the European population, this caused a tripling of real wages between 1350 and 1500. This would mean that the increase in wealth would lead to an increase in human capital investment and the resulting cost per child was higher, reducing fertility (Becker and Lewis, 1973). Although this was the case, fertility had to increase because of the dwindling population. Therefore, since the cost per child increased due to real wages increasing threefold, and since fertility remained high, living standards remained low in the pre-demographic transition. This ties in line with Unified Growth Theory, since mentioned in the theory is the notion that most of the real wage increase during that time was used to boost fertility rates to increase the size of the population (Galor, 2005). This is also the logic Malthus followed in his work on population (1798). Furthermore, fertility rates would fluctuate; periods of high mortality rates caused fertility rates to increase in order to maintain population numbers that were supportable by existing resources, and periods of rising income per capita also increased fertility rates as this induced a rise in the number of surviving offspring due to better infrastructure and nourishment among other things. But from the mid 1500s until the early 1800s, Galor (2005) demonstrates a negative relationship between mortality rates and fertility rates, where increased income per capita was associated with a decline in mortality rates and increased fertility rates from 1680 until 1820[5].

Despite these dynamics of economic development and demographic change being consistent with patterns of change observed during the demographic transition within Unified Growth Theory, the controversy surrounding said theory's part in the discussion surrounding fertility stems from the specific mechanisms suggested (ie. the determinants of fertility limitations and population growth), and the question of their consistency with regards to the empirical evidence (Guinnane, 2011). This reignited the debate on the empirics of the historical fertility transition — namely, the time, the place, the reason it took place, and how quickly it happened. Although Galor (2005) does not explicitly mention the fertility transition in his work, he makes countless mentions of the demographic transition — the sum of the parts of the mortality transition (number of deaths) and the fertility transition (number of births) (Santow, 2001). Some economists, such as Galor, agree that the fertility transition happened across Europe simultaneously (Guinnane, 2011), whereas others disagree due to arguments around data

[5] 1820 is the estimated year generally given for the Great Divergence (Galor, 2005).

collection and methods that the assertion is based upon. One example of a relevant disagreement is the Princeton Project on the Decline of Fertility in Europe, a project undertaken in the 1960’s and 1970’s where the main goal was to characterize the decline in fertility in Europe during the nineteenth and twentieth centuries. Galor has cited this project in his work, despite there being serious problems with its econometrics, measures and sources (Guinnane, 2011), affecting the empirics of any work based on the project.

One standout theory behind the decline in fertility, and evidently the demographic transition, is purely economic. In pre-industrial times, the household production sector was dominant. As defined by Ironmonger in the International Encyclopedia of the Social & Behavioral Sciences (2001, p. 6934), “household production is the production of goods and services by the members of a household, for their own consumption, using their own capital and their own unpaid labor”.

The relationship between fertility and human capital is evident. More labor in the household (quantity of offspring) led to higher levels of gross human capital per household, which meant that there was an increase in the factors of production in general. Children were treated as economic assets in this model. However, transitioning away from the home production sector (around the industrial revolution) meant that children entered the market sector, becoming human capital in a market where quality had a comparative advantage to quantity. Fewer children were then needed to be a part of the household “firm”, which meant that less labor was required, and fewer offspring were born. The amount of human capital parents could provide would then be invested in fewer children, leading to higher levels of human capital per individual. This is further explained by Moe (1997). Fertility is greater with lower levels of human capital, but when human capital reaches a certain threshold, a sharp drop in fertility occurs. The threshold is the point where the household has developed enough human capital to guarantee greater returns in the market sector as opposed to the non-market sector, in this case the household. When parents switch their priorities to the market, the opportunity cost of raising children increases substantially (Moe, 1997). This could be considered an example of a determinant of fertility limitations posed by Galor (2005).

However, the decline in fertility rates is not explained by the change in the value of children economically speaking (Knodel and van deWalle, 1986), although their role changed from the household to the labor market. The aforementioned researchers argue that there was no threshold, either social or economic, needed for the fertility transition to begin, presenting an alternative view to that presented in Unified Growth Theory. The basis for the argument is the alleged lack of consistency in the level of development across Europe. Bulgaria is a prime example; fertility fell by 10% when the population was illiterate, rural and agrarian almost in its entirety (Knodel and van deWalle, 1986).

Further, another item that should be discussed is the possibility of a coordination problem applied to fertility limitations. Coordination problems are found in game theoretical models where players must make decisions based on information available to them, and depending on these decisions, the outcome changes. Kohler (2000) shows that social expectations in this context can sway the decisions of the players. For instance, high fertility can be considered rational if it is the predominant behaviour in a given population, whereas low fertility becomes the rational choice if a large portion of the other members of the community choose to partake. This leads to the possibility of self-fulfilling prophecies — a behavioural economics bias where “a prediction [...] becomes true because of the influence our expectations have on seeing what we want to see" (Finn, 2006, p. 16). In this case, a given economy might remain underdeveloped with high fertility rates because all members of the community believe it will (Kohler, 2012). Therefore, it might have been individual decisions in the past related to herd mentality (the notion that people will follow others around them despite their choices being irrational) that sparked the demographic transition. Moreover, expectations and externalities are extremely relevant when dealing with fertility decisions. These could be manifested as the acceptability and availability of contraception, social norms, or the expected return on human capital (ie. quality of children) (Kohler, 2012). Furthermore, Galor (2005) mentions a hereditary component with regards to fertility; coming to the conclusion that inherited patterns of behaviour affected human capital investment as well (Foldvari and van Leeuwen, 2012). This will be discussed in the next section.

3.2 Biology

> *"From the perspective of the present study the evidence amassed by biologists and anthropologists is of substantive importance, since it makes plausible that the size-number trade-off is a fundamental one. The systematic link between reproduction and body size in economically primitive societies suggests that the trade-off must have been active for a very long time; certainly before the take-off to sustained growth occurred in Western Europe."* — Dalgaard and Strulik, 2015

Some of the controversies in Unified Growth Theory are due to theories that lie outside the realm of economics. One prominent example is found in the field of biology in the form of physiology, directly related to the quantity-quality tradeoff. The quantity-quality tradeoff suggests that the quantity of offspring is counterbalanced by the quality of them. To clarify, having several children implies that the resources available to invest in them would be diminished, leading to a lower investment in the children, such as education and nourishment. On the other hand, having fewer offspring would mean that there are more resources available for them, improving the quality of life the children experience, be it nutritionally, educationally, or the like.

However, this is not the only tradeoff that needs to be considered. Since biologists treat human beings as mammals, theories that apply to mammals generally apply to humans as well. For instance, there is a relationship between the rate of reproduction and body size of parents — the larger the parent, the lower the rate of reproduction (Walker et al., 2008). This relationship is found to be true among not only humans, but other primates. Furthermore, there is evidence showing that it is not only a size-rate tradeoff that occurs among parents, but also a tradeoff between offspring size and family size is present (Hagen et al., 2006). The only tradeoff in Unified Growth Theory was a generalized quantity-quality one, but under the surface there is so much more.

In light of the multiple theories surrounding tradeoffs regarding family and offspring, Dalgaard and Strulik (2015) present what they call a *physiological check* [6] similar to the population checks of Malthus (1798). The theory of Malthusian checks to given populations states that there are preventive or positive checks that keep the population at a given level. Preventive checks are related to conscious decisions to delay marriage due to a lack of resources, while positive checks are unavoidable events or circumstances that shorten the lifespan of humans, such as war and famine. The implications were discussed by Galor (2005, p. 221), where he states:

[6] The physiological check is related to body size: if the human body size increases, subsistence requirements will also increase.

“According to the theory, periods marked by the absence of changes in the level of technology or in the availability of land, were characterized by a stable population size as well as a constant income per capita. In contrast, episodes of technological progress, land expansion, and favorable climatic conditions, brought about temporary gains in income per capita, triggering an increase in the size of the population which led eventually to a decline in income per capita to its long-run level”.

Evidence to the contrary exists, however, when we look at the *physiological check* of Dalgaard and Strulik (2015). They state that income gains that are temporary would translate into higher spending on nutrition for children, which would be an investment in offspring quality, as opposed to an increase in the population size as hypothesized by Malthus, and evidently Galor as seen in the previous paragraph. However, due to the fact that the tradeoff “transcends the human species”, the mechanism of the *physiological check* is then classified in the same way as Malthus’ positive check — in the sense that physiology is an unavoidable circumstance of human nature. Furthermore, the *physiological check* is argued to be a key mechanism in explaining the absence of the growth of income per capita throughout most of human history (Dalgaard & Strulik, 2015).

Weir (1993) presented a theory explaining the height of children over time, and that it is dependent on the allocation of resources between children and adults (ie. the level of food intake). But what was shocking is that the decline in marital fertility and reduction in mortality also contributed to improved heights of offspring. Schneider (1995) also found a negative relationship between fertility and size using data from 9 European countries. Since size is generally a good measure of living standards (Schneider, 1995) then an increase in offspring size implies an increase in living standards, which could be caused by an increase in income, and decreases in fertility and mortality (Weir, 1993). Larger sizes of children also implies that quality has become dominant over quantity when rearing offspring.

Ideas of the limits on population stemming from the fields of biology, anthropology, history, economics and evolutionary ecology have been reviewed in this chapter. The quantity-quality tradeoff is studied in depth from the perspectives of each field as well. As is discernible, the background in this multidisciplinary work is extremely eclectic, with different perspectives on different ideas being presented. The next chapter will take a deeper look at the methodological and theoretical controversies surrounding Unified Growth Theory.

4. Methodological and Theoretical Controversies and Issues

> *"Because no governments collected national-income data and no newspapers reported economic data during those times, Maddison had far less evidence for them than for more recent years, forcing him to make far more assumptions. [...] Galor's regressions on these data therefore do not reveal the contours of early history; they instead reveal how Maddison constructed his data. This observation does not mean that Galor is wrong, only that the apparent precision gained from his sophisticated economic theory and statistical inquiry is illusory."* — Temin, 2012

4.1 Great Divergence Controversy

One of the bases of Unified Growth Theory is the postulate that a takeoff occured from stagnation to growth (Nielsen, 2016). However, this supposed takeoff has been disputed by many researchers. This postulate is twofold. The first is with regards to GDP growth, and the other to population. Unified Growth Theory holds firm that the Malthusian epoch limited both population and growth.

Growth literature, when dealing with the relationship between population growth and economic growth, is inconclusive (Heady & Hodge, 2009). Most of the earlier conclusions were that population had no significant impact on economic growth, but other research showed that there was a negative relationship (such as Petersen, 1959). But a shift in the literature came about in the 1980's, where a positive relationship between population and growth in the long-run became the center of discussion. However, before the turn of the century, literature exploring the negative relationship between the two began to emerge, especially in less developed nations. The different methodologies employed (weighted OLS, panel data) and independent variables used (whether to include fertility rates, health and education) create diversity in the results (Heady & Hodge, 2009). Since fertility was used in unified growth theory, this must be taken into account when analyzing the relationship, and Galor did this quite nicely. By using fertility to impact human capital in his model, he presented the relationship through three stages: Malthusian stagnation, the transition period [7], and the takeoff to the modern growth regime.

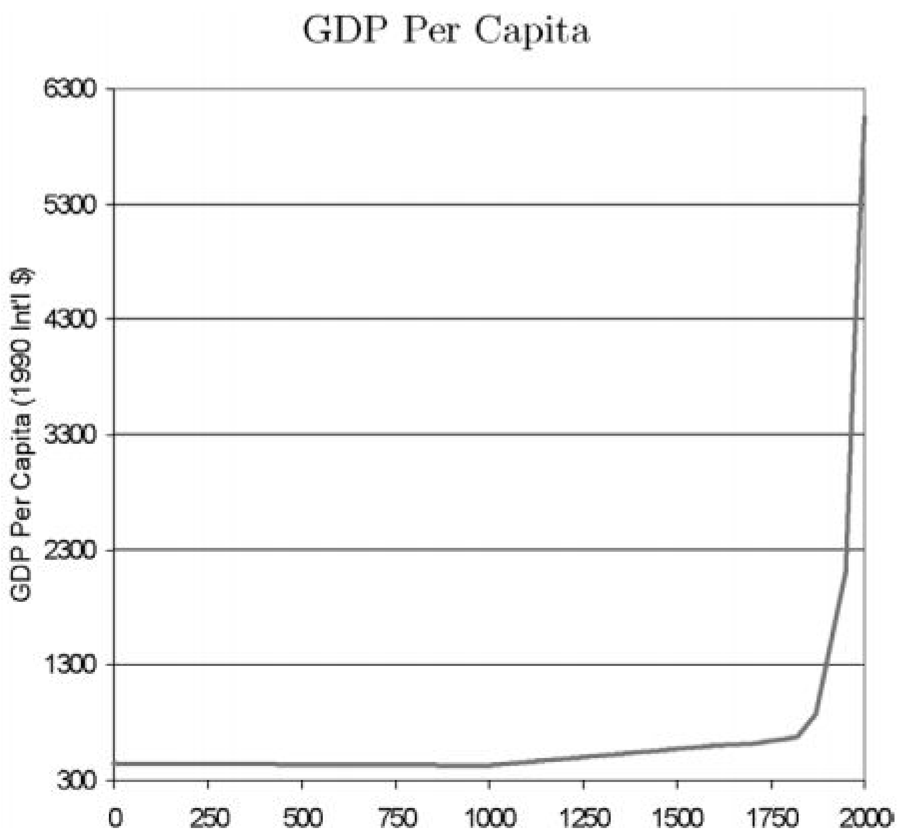

Figure 1: GDP per capita as a function of time 1-2000 (Obtained from Galor, 2005)

[7] This is also known as the turning point in the Great Divergence.

Figure 1 is explained by Galor with the assumption that a takeoff from the Malthusian population trap occured, otherwise known as the Great Divergence. However, the same data (Maddison, 2010) has been analyzed by other researchers and there has been some controversy as to whether the three stages of growth (Malthusian Stagnation, the transition period, and the Modern Growth Regime) as forwarded by Galor (2005) even exist. The opposing viewpoint is that growth, throughout the entirety of human history, has been on one continuous trajectory. This will be discussed in section 4.3.3.

Since the world economy and population numbers grow hand in hand (von Foerster et al., 1960), it is important to study both population and GDP in this regard. For instance, some mathematical models suggest that the world population experienced hyperbolic growth up until the 1970's, whereas the accompanying GDP growth of the world during that same timeframe was quadratic-hyperbolic (Korotayev et al., 2006). A correlation was found between the two curves, and this was attributed to a chain of causation — the more technological growth occurs, the higher the carrying capacity of land will be for people, leading to an increase in population numbers, which in turn allows for more inventors, further boosting technological growth, repeated ad infinitum. This implies a positive relationship between technology and population. However, this also means that there is a positive relationship between technological progress and GDP, a relationship that has been verified and used by many researchers. Although this chain of causation is something extremely similar to Unified Growth Theory (where increased demand for education leading to technological progress serves the same purpose as a higher number of inventors), Korotayev and Malkov (2016) do not mention once the existence of the three regimes of growth, solidifying the notion that the explanations provided in Unified Growth Theory could be used to explain the hyperbolic growth of population and the quadratic-hyperbolic growth of GDP without having to segregate and attribute different parts of the curves to different growth regimes. Despite there being a seemingly positive relationship between technology and population, there has been research that has found otherwise. Some of this research is presented in Section 4.3.2**.**

4.2 Methodological Issues

"...[Unified Growth Theory] can be viewed as a theoretical concept which belongs to the theory of socioeconomic development. It definitely goes beyond the well-established framework of mainstream economics. In comparison with development economics and the theory of economic development and economic history, the unified growth theory by Oded Galor is based on more sophisticated methodological foundations. That obviously makes it more novel, as well as more effective when describing, explaining, and interpreting findings of research on the course of historical transformation process." — Boehlke, 2018

At a glance, and even when digging a little under the surface, Unified Growth Theory is methodologically sound. However, overlapping research questions and biases can take a toll on any published work. Szostak (2015) presents an analysis of overlapping research questions in areas with economists of different perspectives, such as growth theorists and macroeconomists. His initial example of overlap is Unified Growth Theory. He describes the model as one with a threshold effect with a slowly changing causal variable that can instantly have an immense impact on another when it crosses a certain threshold [8]. While this might be the case, he continues "there likely burns within the hearts of all economic historians a desire to explain their

[8] This is not unlike endogenous growth theories, where all limits and thresholds are endogenously determined.

favorite event or process in terms of their favorite small change" (Szostak, 2015, p. 257). Taking a more aggressive approach, Galor was accused of manipulating and distorting data in order to support his own preconceived ideas (Nielsen, 2016). Taking a page from Behavioural Economics, this is an example of confirmation bias. A confirmation bias is, in this case, the tendency to search for and interpret information that further supports one's initial thoughts or beliefs. Therefore, this implies that Unified Growth Theory can attribute any transformation to any slow change due to the inclusion of thresholds. For example, comparing human capital formation and technological advancement would result in some sort of predetermined belief being fulfilled as they are endogenously determined. Therefore, more evidence must be provided for any application of the theory that has been advanced (Szostak, 2015). He concludes "thus our celebration of unified growth theory should be muted at best: it is a tool as likely to lead us into error as into understanding, and one that provides only the first small step in any effort to understand particular growth processes" (p. 258).

Hypothesizing a major shock in a setting where there are various locally stable equilibria would be the simplest methodology that could generate a phase transition from stagnation to growth (Gundlach & Paldam, 2009). But according to Galor in an interview with Brian Snowdon (2008), this is inappropriate since this method is at odds with the Industrial Revolution — an event that is generally seen as a gradual process (Clark, 2007). In comparison, UGT holds that the steady growth of population during the Malthusian Epoch, alongside subtle yet impactful changes in the composition of the population, were what led to the Industrial Revolution. This in line with the gradual process of the Industrial Revolution, which means that the transition from Malthusian stagnation to a growth regime can be captured in one dynamic system, where changes in the quality of institutions play a role in determining the transition. However, one downside is the difficulty explaining why increases in income per capita happened in the past 200 years, instead of the beginning of recorded history.

The purpose of Unified Growth Theory was twofold: the analysis of prehistoric and historical factors that could influence modern processes of development, and the analysis of human evolution alongside the process of growth. Epistemologically and philosophically, UGT uses notions and ideas related to historicism, hermeneutics, evolutionism and empiricism (Boehlke, 2019). Furthermore, since its roots are firmly based in history, this allows for analysis with an empirical basis.

But history is not all that simple to analyze. Braudel (1960) proposes three categories of social time: short time (such as the history of events), time of cycles and intercycles (such as the history of business cycles), and time of secular tendencies (structural history, or the long duration). This means that there are multiple approaches that can be taken to analyze and understand history, but the study of long-run socioeconomic development in works similar to UGT is related to the long duration, where changes have a cyclical and renewable nature (Braudel, 1960).

Acknowledging the key role of technological changes and the changes in and accumulation of human and physical capital respectively indicate an implicit acceptance of the Long Duration forwarded by Braudel. But Galor was not the first, and will certainly not be the last, to try and explain variations in wealth. Rostow (1960), for instance, presented a growth model with linear stages that explained development as a chronological set of five stages that all societies pass through, not unlike the three stages of growth that Galor provided. Comparing the two, we find a lot of similarities, but a few differences and discrepancies. In Rostow's model, the Traditional Society is akin to the Malthusian Epoch of stagnation, while the second stage, dubbed the Preconditions for Take-off [9], would fit the timeframe of the transition between stagnation and the transition period of Galor. The take-off is the same in both models. The next stage in Rostow's model is the Drive to Maturity, where industry diversifies and there is investment in transportation and social infrastructure en masse. Finally, we reach the age of mass-consumption, where consumption of high-value consumer goods, such as vehicles, and mass urbanization occur. One difference in the models is that Unified Growth Theory places the start of urbanization in the era of the Industrial Revolution. However, the final two stages of Rostow's model could generally be likened to the sustained growth regime. Taking a page from Boehlke (2019, p. 9), when we look a bit deeper, it is stated that "in [Galor's] model, development, despite being marked with strong divergence, is ultimately one-directional, progressing from less advanced to more advanced stages… [This] is manifested by associating development with divergence, which is uneven development simultaneously occurring both in time and space". Therefore, questions arise surrounding the "periodization of development" employed by both Galor (2005) and Rostow (1960).[10]

Another issue with the methodological foundation of stages of growth has been discussed by Berger (1986), coming to the conclusion that gradual development does not automatically imply a "mechanical transition" to the stages that follow [11]. However, a review of the literature on economic growth and development processes within economic history allows for eclectic

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[9] This would be when external demand for raw materials spur a structural change in the economy, allowing for widespread increases in technology while keeping income increasing at a less than rapid pace.

[10] Despite the parallels aforementioned, there is another description of human development over the course of history, stemming from physics and related to anthropology (Kapitza, 2006). This will be discussed in section 4.3.3.

[11] This is extremely similar to the threshold effect (Szostak, 2015) described earlier.

interpretations without a clear result. Furthermore, the use of statistics and mathematics increases the accuracy of analysis undertaken by Galor, creating possibilities for empirical verification (Boehlke, 2019). Including pluralism in the theory of development and growth is a generally accepted methodological practice, but it also creates different interpretations of the paths and outcomes of economic growth. Since Unified Growth Theory provides a link between economic history, modern hermeneutic methodologies, evolutionary economics, institutional economics and mainstream economics, while also providing a mathematical and statistical viewpoint, Galor can and should be regarded as a cross-disciplinary innovator with a specialization in growth theory.

4.3 Theoretical Issues

Although different theories exist in the domain of human development depending on the field, some interesting interactions take place between Unified Growth Theory and other domains of research from a theoretical standpoint.

4.3.1 Of Economics and Choice

Persson (2008) makes a bold claim with regards to utility functions and preferences in Unified Growth Theory. He begins by stating that pre-industrial economies had high skill premia, meaning that the difference in wage between skilled and unskilled workers was quite considerable. But if technological progress is stagnant (such as during the Malthusian epoch), quantity is preferred to quality when rearing offspring; if technological progress is high (for example, during the Industrial Revolution), then quality would become the preferred mode of raising children. Here, we find a discrepancy in the theoretical reasoning in Unified Growth Theory when it comes to household preferences in the pre-industrial era.

First, higher parental income leads to more offspring without sacrificing quality (Galor, 2005). Since households have utility functions that cover both quality and quantity of children (Persson, 2008), and assuming that they are capable of planning for the future (which should be expected in the overlapping generation model presented by Galor), then households should be in control of how many children they have, how they invest in said children, and how much income they keep above the subsistence level [12]. These preferences are called "perverse" by Persson, and with good reason. Although there are arguments that attribute a lack of education and cultural norms to the choice of having more or less offspring, I will focus more on individual patterns of behaviour regarding this analysis.

This is a prime example of present bias. A present bias is the inclination to accept a smaller reward, amount of money, endowment etc. immediately as opposed to waiting for a larger one in the future. This is quite common in trade-off situations, and here the tradeoff is between having offspring now (possibly for happiness' sake) and having more money in the future. Therefore, the long-term oriented rational preferences in the model are questionable at best as households do not take the future into account as seriously as they should.

[12] This is an example of a subsistence consumption constraint.

4.3.2 Of Population and Technology

Another theoretical issue is the relationship between population size and technological advancement. As the existing literature is polarized, one of the controversial interactions in Unified Growth Theory is the relationship among two variables, technology and population. There is an alleged positive relationship between population size and technological advancement in the pre-Malthusian world (Galor, 2005), whereas others have found negative or insignificant relationships depending on the era studied. However, if a bigger population makes technological development easier, why did the transition period between the growth regimes kick off in Europe as opposed to China, an area of the world with a larger population? This question was posed by Foldvari and van Leeuwen (2012), referring to Unified Growth Theory's inability to answer the question.

As a unified growth theory, it should be able to present some sort of explanation with regards to this; however, the divergence is attributed to "initial differences in geographical factors and historical accidents and their manifestation in variations in institutional, demographic, and cultural factors, trade patterns, colonial status, and public policy" (Galor, 2005, p. 178, p. 238, p. 280, p. 296). From a geographical perspective, China belongs to the group of advanced cultures outside Europe that formed large isolated empires. However, this hindered their ability to develop new technology, as there was no incentive to do so, leading to a higher crop yield but maintaining a low economic growth rate since the surplus was used to increase quantity, not quality. In Europe, however, smaller nations existed and were extremely competitive, providing many incentives to progress technologically, such as fear of falling behind the competition and innovation to improve the standards of living (Diamond, 2007).

However, looking deeper, Galor argues that the portions of the population that preferred quality to quantity had an evolutionary advantage during the Malthusian epoch. The advantage disappears after the transition occurs, and the amount of quantity-preferring parents would increase, eventually becoming the majority in the population. This is synonymous with the relatively slow development of China compared to Europe, providing a second example about why China's growth stagnated in comparison.

So has there been any definitive result when it comes to the relationship between these two? Crafts and Mills (2007) use a variety of time-series methods to examine economic-demographic interactions during the era of Malthusian stagnation in England. They found that there was a Malthusian economy, but without positive checks to population, with preventive checks disappearing in the mid 1600s. However, they conclude that there is no evidence that technological progress and increasing population sizes feed off each other as presented in Unified Growth Theory.

Other research that has been conducted on the effect of population and technology include Kremer (1993). He explores the relationship between long-run population growth and technology while working within the Malthusian assumption that technology limits population. He finds that the population growth rate was proportional to the level of technology throughout most of human history. Interestingly, however, he states that if population did not adjust instantaneously to increases in income, then the relationship between population and technological change could become insignificant.

Strulik and Weisdorf (2007) use total factor productivity (TFP) growth as a proxy for technology in their paper on a simple unified growth theory while utilizing Malthus' preventative checks (1798). They demonstrate that fertility, and consequently population, respond differently to increases in technology whether it emerges in agriculture or industry. When agricultural productivity increases, then food goods, and subsequently children, become less expensive. However, when industrial productivity increases, then food goods and children become more expensive. When compared to population growth, their results fit the ideas proposed by Galor and Weil (2000), a precursory paper to Unified Growth Theory. The theory forwarded by Galor and Weil was that the drop in fertility (ie. the demographic transition, or population growth) does not begin until TFP growth (ie. technological progress) reaches a certain level. This is clearly illustrated in Figure 2.

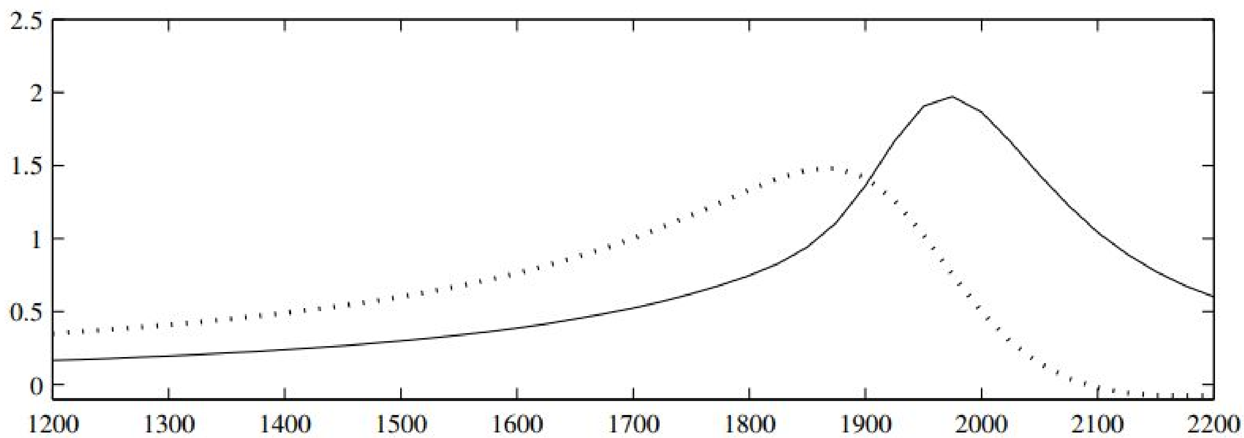

Figure 2: Population growth (dotted) and TFP growth (solid) as a function of time. Obtained from Strulik and Weisdorf (2007).

Before 1875, there is a seemingly positive relationship between population growth and technology. However, around the year 1870 (again, the alleged end of the Great Divergence and the beginning of the Modern Growth Regime), the population growth rate reached its peak and began to decline, whereas technological progress continued to increase, up until its peak in the last quarter of the 20th century, around 1975. This means that there was a negative relationship between TFP growth and population growth for around a century following the end of the transition period (1875 ~ 1975). During this period, the growth of technology kept increasing while population growth slowed down, and this is consistent, both theoretically and chronologically, with the Technological Revolution, otherwise known as the Second Industrial Revolution.

However, what is fascinating is that the doomsday prediction of von Foerster et al. (1960) came true half a century before their first prediction. Although they initially predicted that “doomsday” would happen in 2026, it actually happened in the 1970’s, when the population growth rate was hyperbolic no longer and had reached a point of singularity. This coincides with the peak value of TFP growth as shown in Figure 2, and the start of a positive relationship again between technological progress and population — albeit a diminishing one. What von Foerster missed, however, was that the end of the Technological Revolution would result in a demographic shift, which would explain why their prediction was off by 50 years.

Based on the dynamic relationship between technological growth and population growth, we can indicate three slightly different regimes of population growth when compared to Galor’s epochs (Strulik & Weisdorf, 2007):

1. A positive relationship between advancements in technology and population growth, with increasing returns over time until the 1870’s, where the Malthusian population trap holds

2. A transition period from the 1870's until the 1970's coinciding with the Second Industrial Revolution, where a negative relationship between population growth and technological progress existed — with increasing technological progress and decreasing population
3. A new positive correlation emerges from the 1970's onwards, but the variables diminish over time

These relationships have been supported by various economists in isolation. Bernanke and Guerkaynak (2002) outline a negative correlation that holds in the last century between population growth and that of total factor productivity. Clark (2007), on the other hand, illustrated a positive relationship between the two variables for the pre-industrial period. In Unified Growth Theory, Galor (2005) states that different initial geographic conditions and historical accidents were what led to different timings for the transition period among countries. But the results above are consistent with Galor's description of the end of the transition period: “The Post-Malthusian Regime ended with the decline in population growth in Western Europe and the Western Offshoots (i.e. United States, Canada, Australia and New Zealand) towards the end of the 19th century, and in less developed regions in the second half of the 20th century” (Galor, 2005, p. 185-186). Therefore, we can conclude that the three regimes are consistent with economic history as they have been verified by Galor (2005) and Strulik and Weisdorf (2007) to name a few.

4.3.3 Of Hyperbolic Growth

Because of the fundamentalist nature of physics, those in the field tend to look at the bigger picture. Due to this, when physicists stray from their home and dive into other fields of study, their mentality and way of approaching a problem, issue, or discussion also promotes fundamentalism. Take physics and population growth as an example. In order to properly understand modern population growth mechanics, most state that the entire trajectory of growth from the dawn of mankind must be taken into account. While this is nigh on impossible, plenty of independent estimates have been made in this regard using different methods (Kapitza, 2006).

The physicist von Foerster et al. (1960) first attempted to measure population growth rates by using a very simple yet extremely effective equation to do so:

$$N_t = \frac{C}{t_0 - t}$$

where N is the population at time t, C is a constant, and t_0 is a constant corresponding to a singularity point (or an absolute limit) where population becomes infinite — not literally, however, as a more realistic interpretation is that this is the point where the hyperbolic relationship ceases to exist and a new pattern of growth emerges. The point of singularity was estimated to be Friday the 13th of November, 2026. Shockingly, the R^2 in this model had a value of 0.996, meaning that 99.6% of the variation of world population was accounted for in the model, from 1000 CE to 1970. Although this might seem like an issue of correlation to economists making the model seem unrealistic, there was little to no criticism at the time for von Foerster. In fact, they have been lauded for such a robust model.

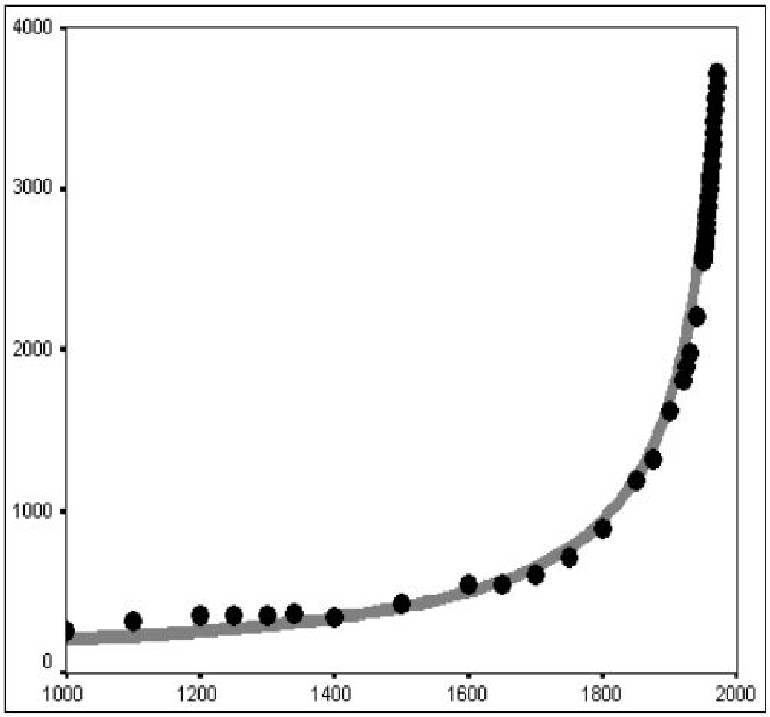

Figure 3: Correlation between empirical estimates of world population (black dots) and the curve generated by von Foerster et al. (1960) (grey line). Obtained from Korotayev et al., 2016.

Since the highly influential discovery presented by von Foerster et al. (1960), there have been others that have followed his example. Astrophysicist van Hoerner (1975) starts with the equation

$$dN/dt = aN$$

where N is population size and a is a certain factor of population growth. If a were constant, then population growth would be exponential, as shown below:

$$N(t) = N_0 e^{at}$$

However, he shows that population growth is not just exponential — it is actually hyperbolic because a singularity point can be determined.

Nielsen (2014) demonstrates that the population growth rate from 10,000 BC was not stagnant as suggested by Unified Growth Theory, but it was actually hyperbolic. This implies that growth has been one continuous motion since the beginning of recorded (growth) history; therefore separating it into three distinct seemingly arbitrary epochs (stagnation, transition, take-off) is “unscientific”. He attributes this alleged mistake to the misinterpretation of early hyperbolic curves as stagnation. Curves related to growth must then be interpreted carefully and as a whole since when left unchecked, growth follows hyperbolic distribution (Nielsen, 2016), as does population (von Foerster et al., 1960). This reinforces the idea of a positive relationship between population and per capita income, which according to Galor (2005), “existed throughout most of human history”. Continuing on his work, Nielsen (2014) uses a simple method of analysis to study the hyperbolic process of the growth of the human population in Africa and the economic growth in Western Europe. He finds that the Industrial Revolution and the surprising technological development that came with it had no impact on economic growth. His models are based on Maddison’s data (2010), the same data used in Unified Growth Theory, taking the reciprocal values of a hyperbolic curve in order to study them linearly. The assumption made is that human population and GDP growth are each driven by one component — hyperbolic distribution — as opposed to having three regimes (stagnation, take-off, modern growth). He finds that the “transition period” occurred in 1870, around the end of the Great

Divergence. However, he does not attribute it to stagnant growth becoming sustained growth, but argues that the same trajectory of growth is being followed.

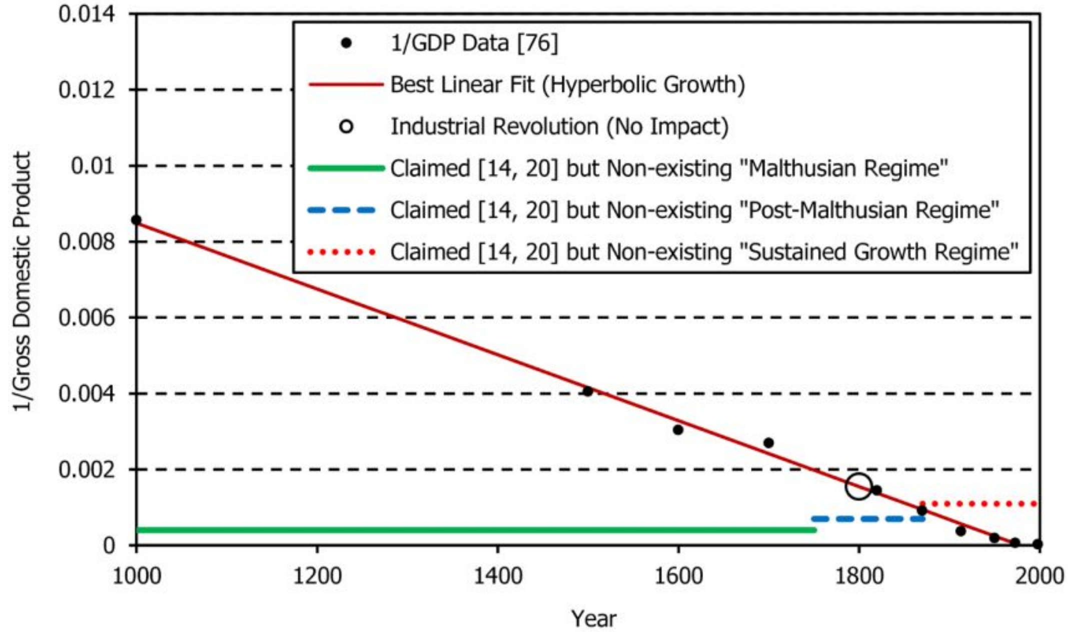

Figure 4: Reciprocal values of GDP growth as a function of time. Obtained from Nielsen (2014).

However, most of the estimates for prehistoric population numbers are close together. Researchers in anthropogeny [13] argue that the evolution of humans from *Homo habilis* to *Homo sapiens* was the first shock to human population growth. This shock sped up population growth, setting the citizens of the world on a quadratic growth curve due to the "collective nature of societal development" (Kapitza, 2006, p. 81). Although the exact timing of this transition is unknown, if linear growth is assumed during this period, then an estimate of the beginning of anthropogenesis can be made.

[13] Anthropogeny differs from anthropology in the sense that the former is the study of human origins, while the latter is the study of human cultures and societies and their development.

In this extreme long-run study of human population, the epochs of growth set by Galor (2005) and Rostow (1960) bar the first are infinitesimally small. Therefore, a new system of epochs must be adhered. One such system is presented by Kapitza (2006), where three epochs that span 4.5 million years are assumed. The first, Epoch A, began 4.5 million years ago and represents the start of anthropogenesis. Linear growth is used to approximate this epoch. The second, Epoch B, described by quadratic growth, lasted from around 1.6 million the middle of the 20th century (one estimate places the start of the transition in the year 1955 until the year 2000). Epoch C, was also defined by quadratic growth afterwards until 2000, the end of a demographic transition. This new demographic transition represents the shift to a stabilized population in a "post-transition" future. While the year 1955 might be an inaccurate estimate of the timing of this new transition, my best bet is that he was off by around 15 years, since 1970 was when hyperbolic growth no longer described population growth, and the relationship between technology and population became positive once more, albeit diminishing (Strulik & Weisdorf, 2007). Furthermore, we notice that population growth is accelerating at a rapid pace, where the duration of each cultural period becomes shorter. A better representation of these epochs and periods is presented in table 1 below.

Epoch	Year	Number of people	Cultural Period	Duration (years)
C	2200	$11x10^9$	Stabilizing Global Population	N/A
	2050	$9x10^9$		125
	2000	$6x10^9$	World Demographic Transition	45
B	1955	$3x10^9$		45
	1840	10^9	Recent	125
	1500	10^8	Middle Ages	340
	500 AD		Ancient World	1000
	2000 BC			2500
	9,000 BC	10^7	Neolithic	7000
	29,000 BC		Mesolithic	20,000
	80,000 BC	10^6	Mousterian	51,000
	220,000		Acheulean	$1.4x10^5$
	600,000	10^5	Abbevillian	$3.8x10^5$
	1.6 million		Oldowan	10^6
A	4.5 million	1	Anthropogen	$3x10^6$

Table 1: The development and growth of mankind (Kapitza, 2006)

So from this perspective, Galor took a curve in one of the three major epochs and arbitrarily split it into three regimes. Although this fits the theory of short term economic growth, population and development, human history is much more dynamic, lengthy, but surprisingly a bit more simple than accounted for in Unified Growth Theory.

Finally, Grinin et al. (2013) explore the differences in biological and social evolutionary mechanisms. In their model, they present evidence that it is the Earth's carrying capacity that is the main driving force of the hyperbolic growth rate of the Earth's population. Interestingly, they allude to the hyperbolic pattern being used in other fields of research as well, stating that "in sociological models of macrohistorical dynamics, the hyperbolic pattern of world population growth arises from nonlinear second-order positive feedback (more or less identical with the mechanism of collective learning) between demographic growth and technological development" (Grinin et al., 2013, p. 212) [14].

4.4 Other controversies

One issue that is occasionally discussed is the lack of policy implications Unified Growth Theory has, despite Galor mentioning that country-wide policies towards education affected the transition timing for countries (Gatti, 2012). In that case, could countries that adopt different educational policies affect their growth? Dinopoulos (2012) states that the work is purely positive, sacrificing normative welfare and policy implications. This is further commented on by Bliss (2013), where he remarks that the state, although a prime driver in economic growth, was only mentioned in passing in Unified Growth Theory.

Other controversies are found at the end of Unified Growth Theory. Foldvari and van Leeuwen (2012) point out the controversial notion that human evolution is interrelated with economic development, where a given trait, be it cultural or genetic, is more favourable under different regimes, providing an advantage to survival — quite similar to the theory of natural selection [15].

[14] This interaction between technology and population was discussed earlier.

[15] This can be linked to the quality-quantity debate, where individuals that preferred quality had a comparative evolutionary advantage in the Malthusian era (Galor, 2005).

5. Controversies in Similar Work

"Given that our work crosses disciplinary boundaries, misconceptions by researchers from other fields are not entirely unexpected, but we hope that our response clarifies the issues raised by our critics and will move the discussion regarding our research towards more productive academic avenues."

— Ashraf and Galor (2013), on the controversy surrounding their "Out of Africa" Hypothesis

A related controversy that was merely mentioned in passing in Unified Growth Theory is that of the relationship between sociocultural or genetic diversity and economic growth. Galor (2005) alludes to socio-biological evolutionary foundations being instrumental to understanding the growth process. However, a few years later, Ashraf and Galor (2013) developed their most controversial work yet: The "Out of Africa" Hypothesis. They attempt to explain the wealth of Europe and former European imperialized nations, the moderate income of east Asia, and the lack of wealth found in Latin America and Africa. How do they do this? By attributing wealth to genetic diversity.

Their paper presents a hump-shaped curve, outlining the trade-off between diversity and productivity based on migratory distance to different regions of the world. Some areas of the globe, such as Africa, have extremely high genetic diversity, whereas other regions, like Latin America, are on the other end of the spectrum, have low diversity. Moderately diverse societies, such as Europe and Asia, experienced much higher levels of development and economic growth than their counterparts. The analysis was based on deep-rooted factors that were predetermined tens of thousands of years ago. However, cross-country migrations during the years of colonization had an impact on genetic diversity in countries that were colonized (Ashraf & Galor, 2013). However, this is just one explanation of the variation in wealth across nations. A decade and a half prior, Landes (1998) in his award winning book *The Wealth and Poverty of Nations* attributed the dominance of the West to either one of two explanations:

- The organization, intelligence, hard work and innovation that spawned in Europe
- The aggression, greed and ruthlessness of the Europeans (referring to colonization hindering the development of African nations)

While not making a mention of predetermined genetic factors playing a role in the variation in levels of development.

Ashraf & Galor (2013) claimed that they used genetics as a proxy for other driving forces in an economy, for example, culture and history. But this paper was a big step forward for genoeconomics, the field that blends genetics and economics. The “Out of Africa” Hypothesis was one of the first works related to this field, and it is this domain that could have real-life implications for policymakers. Ideas such as reducing barriers to information, innovation and ideas across cultures and populations could be developed, increasing the speed at which the human race develops. However, in practice this is quite tricky to uphold.

This caused an uproar in the field of anthropology, with prominent anthropologists taking a stance against them as presented by the statistician Gelman (2013). One of the arguments was surrounding the empirics used and the interpretation of the coefficients. For example, Ashraf and Galor present data indicating that a 1 percentage point increase in diversity would raise Bolivia’s per capita income by 41% (Bolivia was the most homogenous country), whereas a 1%

point decrease in Ethiopia's diversity (the most diverse country) would increase per capita income by 21%. But how does one increase genetic diversity by 1%? Would you transport people from all over the world to Bolivia, or would you choose a specific region to diversify? Decreasing genetic diversity by 1% poses the same question. What were the implications of the research then?

Ethically, the criticism of anthropologists also led to the conclusion that racist attitudes could be fed through the paper [16]. However, what is more pressing is the problem in the publication system, where making a bold claim and defending it using empirical analysis is preferred to exploration of any given topic. This is related to Setterfield's work on improving communication between different perspectives on growth theories, leading to the possibility of greater engagement (2013). He states that the majority's self interest (in this case, the field of economists) does not involve searching for opposing points of views, as it increases the cost of intellectual reproduction. This is an example of confirmation bias, and this is apparent in some major journals — where peer-reviewed articles are either dominated by the in-group favouritism of the referees, or by confirming their beliefs. This is one of the reasons why the communication between disciplines, or even supporters of different theories within the same field of study, are distorted.

Another flurry of criticisms was presented by Guedes et al. (2013) (the anthropologists in question), where they summarize and critique the paper under fire. They present arguments related to misunderstanding specific scientific concepts and terminology, factual errors in data, and simplistic assumptions about the nature of human behaviour. Furthermore, they claim that

[16] This will be elaborated on page 45.

the level of genetic diversity among humans is much lower than when compared to the levels in other organisms, such as chimpanzees, our closest cousins. Shockingly, some bonobo and chimpanzee clades found in West Africa have higher mitochondrial variation than is seen in the entire human species (Gagneux et al., 1999). This spawns the argument that the genetic differences compared to other species is miniscule, and does not warrant investigation. Although Guedes and her colleagues do praise the intention and ambition of the researchers in question, the anthropologists suggest consulting with specialists when dealing with interdisciplinary work in order to “avoid making such uninformed blunders” (Guedes et al., 2013, p. 77).

In one of the responses to criticism from other fields, Ashraf and Galor (2013) point to several misconceptions in their research in order to reconcile the interdisciplinary relationship, neatly revisiting some of the criticisms thrown their way in an elegant fashion. The first was to do with imperfect population data, especially that of native American societies in the precolonial period. However, the historical analysis employed by the researchers accounted for measurement errors, which meant that the validity of their empirical findings were actually robust.

The second main criticism was the use of neutral (genotypical, or hidden) genetic markers used as a proxy of interpersonal diversity. Since they do not represent diversity in functional (phenotypical, or visible) markers, then they cannot influence behavioural and social interactions. While this is a valid argument, the intention of Ashraf and Galor was to analyze the data based on predicted diversity, and not the observed level. However, what this analysis allowed them to do was create a pseudo “proxy for a proxy” — they used migratory distance from Africa as a proxy for predicted diversity, which is, in of itself, a proxy for visible traits that could shape behaviour. While this might be a methodological practice uncommon in the field of anthropology, what is found in physical anthropological research, however, is that there is evidence suggesting that distance from sub-Saharan Africa is the most causal factor to explain phenotypic diversity found within-population (Betti et al., 2008).

The last misconception, and arguably the most impactful, is the assertion that a level of diversity that maximizes productivity exists, and the policy prescriptions it has. Although the “Out of Africa” Hypothesis is extremely beneficial in understanding the roots of our differences, the policy implications should be taken at face value. One of the few policy implications that would be detrimental to the fabric of society is manipulating genetic diversity in underdeveloped countries in order to improve cooperation, alleviate poverty, and improve productivity, which were some of the results found that a certain range of diversity within a country could have. This was the concern of “uninformed critics” (Ashraf et al., 2018, p. 8). But the problem with the social sciences is that most, if not all work should have normative effects on society. So if we were to apply the aforementioned policy implication to a real world setting, then eugenics could be applied based on the belief of genetic determinism, promoting racist attitudes and repeating dark times in history. But what the researchers suggest is not to use the results to construct policies, but to provide a deeper understanding of the impact a genetic makeup of a society has. They recommend improving education policy with a focus on respecting pluralism, which would then mitigate the costs of diversity (or lack thereof), improving economic prosperity by increasing the importance of diversity and the understanding of its effect.

Other economists have also grown fond of genoeconomics and have dived right in. Spolaore and Wacziarg (2009) explore the difference in per capita income across countries using genetic distance, “a measure based on aggregate differences in the distribution of gene variants across populations” (p. 469). They find that genetic distance is correlated with differences in income while controlling for plenty of issues such as geographic distance, transportation costs, religious distances and climatic differences to name a few. While their results are similar to the results of Ashraf and Galor (2013), their research did not invoke as much uproar as the latter.

In this ongoing debate, economists would tend to take the side of Ashraf and Galor (partly due to the formation of in-group biases and favouritism), although the anthropologists present clear and concise arguments. The methodological disparities and the means in which results are used in each field are bound to create misunderstandings, as is more often than not the case in interdisciplinary work. But if the researchers in the hot seat can take anything from the backlash of the anthropologists, it’s to consult, or at least discuss, ideas with experts in fields outside one’s own when crossing disciplines.

6. Impact of UGT on Growth Economics

Finally, we reach a brief study on the impact of Unified Growth theory on growth economics as a whole. In order to discuss the impact of Unified Growth Theory, the concept of a research routine must be defined. A research routine "represents a pattern of research practices of a scientific community which share a common symbolic representation[17] and focuses on the evolutionary continuity of progress in science" (Kawalec, 2020). The example at hand, economic growth theories, would be the main routine, whereas Unified Growth Theory would be a subroutine in this field, as are exogenous and endogenous growth theories to name a few others.

Initially, it seems as though UGT has taken all of its ideas from the main routine except the concept of the demographic transition (Kawalec, 2020). Furthermore, new keywords in papers related to growth economics average 2.5 per paper in the main routine and 1.7 in UGT. This would imply that the increase in popularity of UGT has been influenced by the main routine. But despite these dependencies, UGT has undertaken an independent evolution staying clear of the rest of the growth literature. This is evident as the most important contributors to the main routine (fn such as Romer, Solow, Lucas) are cited much less in papers relating to the subroutine, implying that they are not the focal point — Galor is. This is presented in Figure 5.

[17] Such as a model or theory

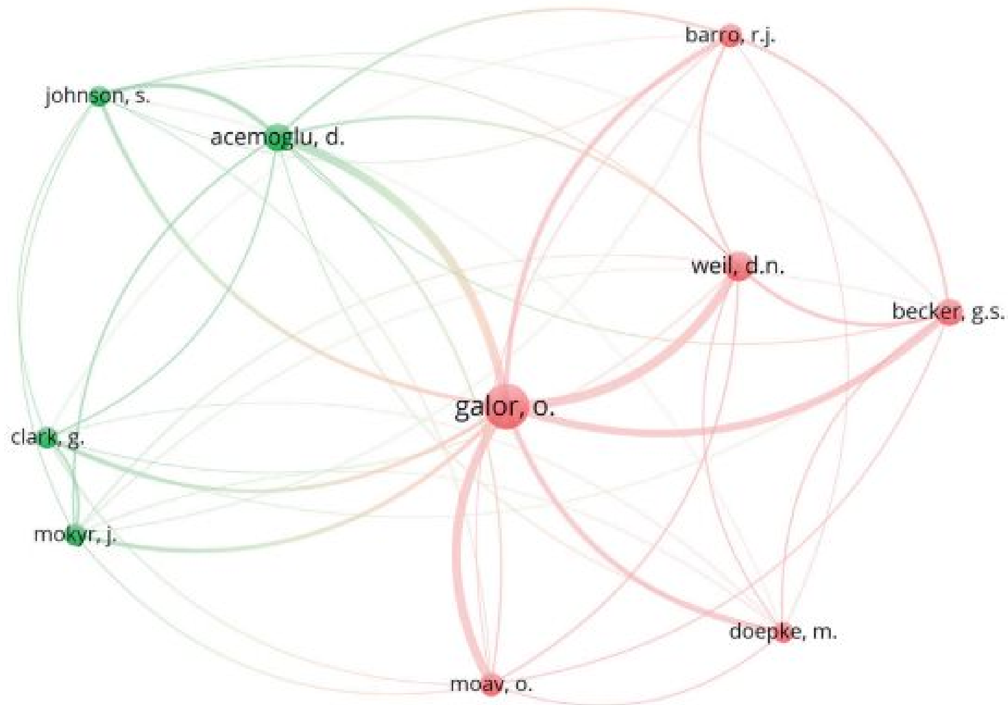

Figure 5: The co-citation network in the UGT subroutine (top 10 cited authors). Retrieved from Kawalec, 2020.

Using “demographic transition” as the symbolic representation of UGT (as it was the main key term not taken from the rest of the economic growth literature), Kawalec (2020) presents data showing that the keywords used in the main routine related to demographic transition have about the same frequency as UGT does (albeit in a much smaller dataset), which would imply a permanent shift in the main routine due to changes in the subroutine that is Unified Growth Theory. “This is best evidenced by how the concept of demographic transition altered the essential concepts of the main routine, such as human capital, population growth and learning” (Kawalec, 2020, p. 37).

However, one important issue of economic networks and cognitive biases must be discussed, especially in the light of lesser known publishers and researchers contributing to and criticising existing literature. Networks have a community structure, which implies that nodes in a given network will be more likely to interact with each other than across different communities and networks (Fortunato, 2010). This is generally seen as homophily (the tendency to search for people with similar points of view to one's own), which more often than not leads to in-group biases. Going back to Setterfield (2013), this would mean that co-citations are a form of in-group favouritism, and communication within the field is biased. Furthermore, ideas and perspectives on growth (be it population or economic) such as Nielsen (2016) and Korotayev (2006) coming from outside the main group of growth economics have a very slim chance of being published in top economic journals due to the nature of the academic world and networks that exist within. The sooner this issue is addressed, the earlier a true academic discussion would be able to flourish, where insights from physics, biology, anthropology, history and economics could combine to produce knowledge at its purest.

7. Limitations, recommendations for future research, concluding remarks

The aim of this paper was to bring to light the different controversies surrounding Unified Growth Theory. It can be likened to a magnificent piece of art such as the Mona Lisa — although fascinating to observe, the longer you look at it the more flaws you find, but in the end, you end up appreciating it and accepting it with all its blemishes. In this paper some of the controversies surrounding Unified Growth Theory were discussed from the perspectives of different fields of research. I attempted to take the reader on the most interesting path through the theory from these perspectives, from the Great Divergence to fertility limitations and transitions to the relationship between population and technology, and beyond. I presented a discussion on the methodological and theoretical issues that have shaped the controversies as a whole, while briefly studying the impact Unified Growth Theory has had on its main routine, growth economics.

As with all work, this paper is certainly not without its flaws. Some of the sources used are not widely accepted in mainstream economics, which can be attributed to a lack of willingness for researchers to look for opposing viewpoints outside their domains (Setterfield, 2013). Furthermore, time limitations were another factor. My lack of expertise in fields outside economics must have also hindered the quality of this work, and I find myself in the same predicament Ashraf and Galor did — without consultation from experts beyond the field of economics.

Recommendations for future research include a rigorous analysis of the data and methods used by Galor (2005), despite Unified Growth Theory mainly being a theoretical work. Other articles discussing the impact of physical capital would also be relevant in order to better capture the interactions among all the relevant variables. One possibility of future research could be normative instead of positive — whether there are any policy implications for Unified Growth Theory or not. Exploring the interactions among different fields of research related to economic growth is another avenue that could be travelled down. Lastly, discussing the impact of different political systems [18] on growth in general is an avenue that I wish I had the time to explore. However, I wish the best of luck to future researchers willing to dive into this rich topic.

[18] The difference between the impact of capitalism and communism is a factor in technological development (Berger, 1986).

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