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Unified Growth Theory contradicted by the absence of takeoffs in the Gross Domestic Product

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Abstract. Data describing historical economic growth are analysed. They demonstrate convincingly that the take offs from stagnation to growth, claimed in the Unified Growth Theory, never happened. This theory is again contradicted by the same data which were used, but never properly analysed, during its formulation. The absence of the claimed takeoffs demonstrates that the postulate of the differential takeoffs is also contradicted by data. Furthermore, this analysis demonstrates that the mathematically-analysable data contradict the concept of the prolonged Malthusian stagnation, its effects on the economic growth as well as the concept of a dramatic escape from the Malthusian trap.
Keywords. Historical economic growth, regimes of growth, Malthusian stagnation, takeoffs, Malthusian trap, hyperbolic growth.
JEL. A10, B10, B22, F01, N10.

1. Introduction

One of the fundamental postulates of the Unified Growth Theory (Galor, 2005a, 2011) is the postulate of takeoffs from stagnation to growth. This feature is supposed to mark a boundary between the ages-long epoch of Malthusian stagnation and a new epoch of a rapid economic growth. An easy way to test the Unified Growth Theory is to look for such postulated takeoffs because they should be easily identifiable. The added advantage of using this test is that it also checks the validity of yet another postulate of this theory, the postulate of the differential takeoffs.

In our analysis we shall use the excellent data published by the world-renown economist (Maddison, 2010). The data presented in this compilation are virtually the same as in his earlier compilation (Maddison, 2001), which Galor was using during the formulation of his Unified Growth Theory. The difference between the two compilations is that the new set of data was extended to the 21st century. These extended data are not essential for testing the Unified Growth Theory but they help in demonstrating the latest transitions from the historical hyperbolic growth to slower trajectories. Unfortunately, Galor did not analyse Maddison's data. His interpretations of the mechanism of economic growth are based on strongly questionable quotations of isolated numbers, on the unfortunate simplistic and self-misleading examination of data and on the habitual use of grossly distorted diagrams (Ashraf, 2009; Galor, 2005a; 2005b; 2007; 2008a; 2008b; 2008c; 2010; 2011; 2012a; 2012b; 2012c; Galor & Moav, 2002; Snowdon & Galor, 2008).

Historical economic growth and the growth of human population can be described using hyperbolic distributions (Nielsen, 2014; 2015a; 2015b; 2015c; 2015d; 2016a; 2016b; 2016c; 2016d; von Foerster, Mora & Amiot, 1960) Unlike the better-known exponential growth, which is easier to understand, hyperbolic distributions are strongly deceptive because they appear to be made of two distinctly different components, slow and fast, joined perhaps by a certain transition component. This illusion is so strong that even the most experienced researchers can be easily deceived particularly if their research is based on a limited body of data, as it was in the past. Fortunately, Maddison's data solve this problem, and fortunately also their analysis is trivially simple because, as pointed out earlier (Nielsen, 2014), hyperbolic distributions can be easily identified and analysed using the reciprocal values of data. Consequently, if in the past, researchers were basing their conclusions on the strongly-limited sets of data and imagined that there was a prolonged epoch of stagnation followed by sudden takeoffs in various geographical regions, now there is no excuse to continue with such interpretations because we have excellent sets of data, which lead to the entirely different conclusions. It is, therefore surprising, if not disappointing, that Galor, who had access to these excellent data and even used them during the formulation of his theory, did not analyse them properly but followed the traditional and incorrect interpretations of the historical economic growth.

Theories play an important role in scientific research because they crystallise interpretations of studied phenomena. However, theories have to be always tested by data. In science it is important to look for data confirming theoretical explanations but it is even more important to discover contradicting evidence, because data confirming a theory confirm only what we already know but contradicting evidence may lead to new discoveries.

According to Galor, historical economic growth can be divided into three distinctly-different stages governed by three distinctly different mechanisms: (1) the Malthusian regime of stagnation, (2) the post-Malthusian regime, and (3) the sustained-growth regime. We have already demonstrated that this postulate of the three regimes of economic growth is contradicted by the data for Western Europe, Eastern Europe, Asia, countries of former USSR, Africa and Latin America (Nielsen, 2015a; 2015b; 2015c; 2015d; 2016b), ironically by the same data which were used but never analysed by Galor.

This fundamental postulate of the three regimes of growth is used repeatedly throughout the narrative of the Unified Growth Theory and serves as the essential support for the discussed interpretations and explanations. Without this corner stone the whole theory becomes unsupported.

According to Galor, "The take-off of developed regions from the Malthusian Regime was associated with the Industrial Revolution and occurred at the beginning of the 19th century, whereas the take-off of less developed regions occurred towards the beginning of the 20th century and was delayed in some countries well into the 20th century" (Galor, 2005a). Even more precisely (Galor, 2008a; 2012a), Malthusian regime of stagnation was supposed to have been between 100,000 BC and AD 1750 for developed regions and between 100,000 BC and AD 1900 for less-developed regions. The post-Malthusian regime was allegedly between AD 1750 and 1850 for developed regions and from 1900 for less-developed regions. The sustained-

growth regime was supposed to have commenced around 1850 for developed regions.

The claimed starting time of the Malthusian regime appears to be based entirely on conjecture because Maddison's data are terminated at AD 1 and even they contain significant gaps below AD 1500. The claimed date of 100,000 BC is also hanging in the middle of nowhere because the origin of *Homo sapiens* is usually placed around 200,000 BC. However, Weaver, Roseman & Stringer (2008) have pointed out that the divergence of the lineages of modern humans and Neanderthals might have occurred around 309,000 BC or even 433,000 BC.

We have no mathematically analysable data over such a long time so any claim of the existence of Malthusian stagnation in the economic growth in the distant past is based on questionable conjectures. However, we have mathematically-analysable data describing the growth of the population from 10,000 BC and they show that the growth of the population was not stagnant but hyperbolic not only during the AD era, as pointed out over 50 years ago by von Foerster, Mora & Amiot (1960) but also during the BC era (Nielsen, 2016c).

Hyperbolic growth was slow in the past but it was not stagnant. Slow hyperbolic growth should never be interpreted as stagnant because if we want to interpret the slow hyperbolic growth as stagnant, and governed by the usually assumed multitude of random forces, we should use precisely the same mechanism to explain the fast hyperbolic growth. It is impossible to divide the monotonically-increasing hyperbolic distributions into slow and fast components (Nielsen, 2014). Hyperbolic distributions have to be interpreted as a whole and the same mechanism has to be applied to the apparent slow growth and to the apparent fast growth. There is no clearly defined transition between the apparent slow and the apparent fast growth.

The alleged transition at the end of the postulated regime of Malthusian stagnation for various regions and countries is described by Galor as "the sudden take-off from stagnation to growth" (Galor, 2005a, pp. 177, 220, 277), as a "sudden spurt" (Galor, 2005a, 177, 220)or as "remarkable" or "stunning" escape from the Malthusian trap (Galor, 2005a, pp. 177, 220). It is a signature, which cannot be missed.

For developed regions, this signature is supposed to have coincided with the onset of the Industrial Revolution, 1760-1840 (Floud & McCloskey, 1994). Indeed, Industrial Revolution is considered to have been "the prime engine of economic growth" (Galor, 2005a, p. 212).

The signature of the takeoffs is characterised by three features: (1) it should be a prominent change in the pattern of growth, (2) it should be a transition from stagnation to growth and (3) it should occur at the time claimed by the theory. For developed regions, the postulated takeoffs should occur around AD 1750. For less-developed regions, they should occur around 1900.

A transition from growth to growth is *not* a signature of the postulated takeoff from stagnation to growth. Thus, for instance, a transition from hyperbolic growth to another hyperbolic growth is not a signature of the sudden takeoff from stagnation to growth. Likewise, a transition at a distinctly different time is not a confirmation of the theoretical expectations.

We shall now demonstrate that the postulated takeoffs never happened and consequently that the concept of the differential takeoffs is contradicted by data, because in the absence of takeoffs it makes no sense to claim that they occurred at different times for different regions. In the future we shall also demonstrate that "The mind-boggling phenomenon of the Great Divergence" (Galor, 2005a, p. 220) is mind-boggling only because it is hard to understand how anyone familiar with mathematics could be puzzled by such an artificially-created structure. If hyperbolic distributions are not properly analysed they can be used to generate such phantom and totally meaningless features. Scientific analysis of Maddison's data opens a new outlook on the interpretation of the historical economic growth.

Throughout the analysis presented here, the values of the Gross Domestic Product (GDP) will be expressed in billions of the 1990 International Geary-Khamis dollars. Parameters describing the fitted distributions were determined by the mathematical analysis (Nielsen, 2016b) of Maddison's data (Maddison, 2010).

2. World economic growth

Results of mathematical analysis of the world economic growth are presented in Figure 1. If the Unified Growth Theory (Galor, 2005a; 2008a; 2011; 2012a) is correct, we should see clear signs of *two* takeoffs: around 1750 for developed regions and around 1900 for less-developed regions. We see none of them.

The data and their analysis are in the direct contradiction of this theory. They show that the economic growth was remarkably stable and that the claimed or wished-for takeoffs never happened. The absence of the two claimed takeoffs is strikingly conspicuous. Galor's claim of the "spectacular" or "stunning" escapes from Malthusian trap (Galor, 2005a, pp. 177, 220) is spectacularly and stunningly contradicted by the analysis of the economic-growth data, the same data, which he used, but never properly analysed, during the formulation of his theory.

The absence of the takeoffs has been also demonstrated for the income per capita data (GDP/cap) for the world economic growth (Nielsen, 2015e). In science, such single demonstration would have been sufficient to show that the Unified Growth Theory needs to be revised to bring it in agreement with data, however, when closely analysed this theory is found to be repeatedly contradicted by data (Nielsen, 2015a; 2015b; 2015c; 2015d; 2015e; 2016a; 2016b).

Hyperbolic growth of the world economy is in harmony with the hyperbolic growth of the world population (Nielsen, 2016c; von Foerster, Mora & Amiot, 1960). In both cases, the growth was indeed slow over a long time and fast over a short time. In both cases the growth creates an illusion of stagnation followed by a sudden takeoff. However, in both cases the growth was hyperbolic. There was no stagnation and no sudden takeoff. Furthermore, in both casesthe growth started to be diverted, relatively recently, to slower trajectories.

3. Western Europe

The growth of the GDP in Western Europe is shown in Figure2. Results of analysis show that there was no takeoff from stagnation to growth because

(1) there was no stagnation and (2) because the economic growth, which is described well by the hyperbolic trajectory, was stable during the time of the alleged takeoff. The takeoff simply did not happen.

The claim of the stunning or remarkable takeoff is contradicted by data. There was no takeoff of any kind, stunning or less stunning, remarkable or less remarkable, sudden or gradual; none at all. The Industrial Revolution, the alleged "prime engine of economic growth" (Galor, 2005a, p. 212), made no impression on changing the economic growth trajectory in the region where this engine should have been working most efficiently. Industrial Revolution brought many other important changes but, surprisingly perhaps, did not change the economic growth trajectory in the countries closest to this monumental development.

4. Eastern Europe

The analysis of the historical data for Eastern Europe is summarised in Figure3.There was no stagnation and no takeoff at any time. Industrial Revolution had no impact on changing the economic growth trajectory in the countries of Eastern Europe.

5. Former USSR

The analysis of the data for the countries of the former USSR is presented in Figure4.There was no stagnation and no takeoff at any time. Industrial Revolution had no impact on changing the economic growth trajectory in the countries of former USSR.

6. Asia

Analysis of the historical economic growth in Asia is summarised in Figure 5. Asia is made primarily of less-developed countries (BBC, 2014; Pereira, 2011) and consequently, according to the Unified Growth Theory (Galor, 2005a, 2008a; 2011; 2012a), economic growth in this region should have been stagnant until around 1900, the year marking the alleged stunning escape from Malthusian trap, the escape manifested by the postulated dramatic take off.

The data and their analysis show that there was no stagnation and no claimed takeoff from stagnation to growth. The data reveal a steadily increasing and stable hyperbolic growth until around 1950. From around that year, economic growth *was* diverted to a slightly faster trajectory. This boosting occurred close to the time of the postulated takeoff from stagnation to growth. However, it was *not* a transition from stagnation to growth but from growth to growth.

It should be noted that this temporary boosting is now returning to the original hyperbolic trajectory and is likely to move to the other side. It is already following a slower trajectory, because its gradient is smaller than the gradient of the historical trajectory. It would be interesting to explore and explain the mechanism of this boosting but we shall not find its explanation in the Unified Growth Theory. This theory does not even notice this feature.

7. Africa

Results of the analysis for Africa are presented in Figure 6.Africa is also made of less-developed countries (BBC, 2014; Pereira, 2011) so according to the Unified Growth Theory (Galor, 2005a; 2008a; 2011; 2012a) it should have experienced stagnation in the economic growth until around 1900 followed by a clear takeoff from stagnation to growth around that year. These expectations are contradicted by the economic growth data because (1) economic growth was not stagnant but hyperbolic (Nielsen, 2015d; 2016b), (2) there was no takeoff from stagnation to growth around 1900 or around any other time(3) shortly after the expected time of the takeoff, economic growth in Africa started to be diverted to a slower trajectory.

As discusses elsewhere (Nielsen, 2015d; 2016b), there was an acceleration in the economic growth in Africa around 1820. However, this acceleration occurred significantly earlier than the expected takeoff around 1900 and it was not a transition from stagnation to growth but from growth to growth. Even more specifically, it was a transition from the hyperbolic growth to another hyperbolic growth. This acceleration can be explained by noticing that it appears to coincide with the intensified colonisation of Africa (Duignan & Gunn, 1973; McKay, Hill, Buckler, Ebrey, Beck, Crowston, & Wiesner-Hanks, 2012; Pakenham, 1992). The fast increasing GDP after 1820 was not reflecting the rapidly improving living conditions of the African population brought about by the beneficial changes caused by the Industrial Revolution but the rapidly increasing wealth of new settlers and their countries of origin at the expense of the deploring living conditions of the native populations.

The takeoff from stagnation to growth, claimed by the Unified Growth Theory (Galor, 2005a; 2008a; 2011; 2012a),did not happen in the region where it should have been prominently present. Economic growth was always stable in Africa (Nielsen, 2015d; 2016b) and now it is being diverted to a slower trajectory. Escape from the Malthusian trap never happened because there was no trap. Economic growth was never stagnant in Africa but hyperbolic.

8. Latin America

Results of the analysis of the economic growth in Latin America are presented in Figure 7. Latin America is also made of less-developed countries (BBC, 2014; Pereira, 2011) so again, according to the Unified Growth Theory (Galor, 2005a; 2008a; 2011; 2012a), economic growth in this region should have been stagnant until around 1900 and fast-increasing from around that year. This pattern of growth is stunningly contradicted by data, the same data, which were used, but never properly analysed, during the formulation of this theory. At the time of the claimed "stunning" and "remarkable" escape from Malthusian trap (Galor, 2005a, pp. 177, 220) economic growth in Latin America was already diverted to a *slower* trajectory.

9. Summary and conclusions

Results of the mathematical analysis of Maddison's data (Maddison, 2010) show convincingly that takeoffs from stagnation to growth, claimed repeatedly in the Unified Growth Theory (Galor, 2005a; 2008a; 2011; 2012a)

never happened. The growth of the GDP was not stagnant but hyperbolic and, in general, remarkably stable.

It is essential to understand that claims about the existence of the epoch of Malthusian stagnation in the economic growth or in the growth of human population are not supported by the scientifically-analysable data. They are based on conjectures and impressions and they introduce the unwelcome and undesirable ballast in the economic and demographic research, directing them into unproductive channels, which move the economic and demographic research away from science and develop them into a fiction, because in the absence of scientifically analysable data the concepts of stagnation and of the dramatic escape from the mythical Malthusian trap are supported by creative writing.

A clear way of demonstrating that the doctrine of Malthusian stagnation and its effects on the economic growth or on the growth of human population is incorrect is by demonstrating the absence of the takeoffs from the alleged stagnation to growth. As demonstrated here, such takeoffs did not exist in the economic growth. They also did not exist in the growth of human population (Nielsen, 2016c; 2016d). Demographic Transition Theory, the only theory used by demographers to explain the historical growth of human population, also claims the existence of Malthusian stagnation followed by a dramatic takeoff from stagnation to growth but this theory is repeatedly contradicted by data (Nielsen, 2016e).

Slow economic growth or the growth of human population is routinely interpreted as stagnation but such interpretations are incorrect because the slow growth is an integral part of the hyperbolic growth, which cannot be divided into slow and fast components (Nielsen, 2014) and which has to be interpreted as a whole by using the same mechanism for the whole distribution. We already know that the growth of human population during the AD and BC eras was not stagnant but hyperbolic from at least 10,000 BC (Nielsen, 2016c; von Foerster, Mora & Amiot, 1960). We do not have mathematically-analysable data for the economic growth over such a long time, but the data we have (Maddison, 2010) show conclusively that during the time described by these data, economic growth was also hyperbolic and consequently that it was not stagnant. Furthermore, we have also proven that Galor's concept of the existence of the three regimes of growth is contradicted by the analysis of the economic growth in Western Europe, Eastern Europe, Asia, countries of the former USSR, Africa and Latin America (Nielsen, 2015a; 2015b; 2015c; 2015d; 2016a).

There is no scientific support for the concept of Malthusian stagnation and for the dramatic escape from the Malthusian trap, which is supposed to have been manifested in the dramatic takeoffs. Mathematically analysable data describing economic growth and the growth of human population show repeatedly and consistently that takeoffs from stagnation to growth never happened because there was no stagnation. Mathematically analysable data show repeatedly and consistently that the economic growth and the growth of human population were hyperbolic. Concepts of prolonged stagnation followed by a "remarkable" or "stunning" escape from Malthusian trap (Galor, 2005a, pp. 177, 220) are repeatedly and consistently contradicted by data.

In science, such overwhelming evidence would have been more than sufficient to show that the theory is unacceptable and that it should be either thoroughly revised or rejected and replaced by a more suitable theory, a theory based on a scientific analysis of data, a reliable theory, which could be used in the economic growth research. In its present form, Unified Growth Theory is neither reliable nor useful. In fact it is strongly misleading.

Our analysis of Maddison's data (Maddison, 2010) shows not only that the concept of Malthusian regime of stagnation followed by dramatic escapes from Malthusian trap is incorrect but also that the concept of the differential takeoffs is incorrect because we cannot have differential takeoffs without takeoffs.

Unified Growth Theory is riddled with questionable claims and interpretations. In due time, we shall demonstrate that this theory is contradicted by regional GDP/cap data in much the same way as it is contradicted by the global data (Nielsen, 2015e). We shall show that this theory is contradicted by the economic growth in the UK, the centre of the Industrial Revolution where the Unified Growth Theory should have the strongest support. It can be also shown that this theory is contradicted by the economic growth in other individual countries.

We shall demonstrate that the postulate of the great divergence is also based on the incorrect interpretation of the mathematical properties of hyperbolic distributions. Furthermore, we shall demonstrate that Galor's repeated interpretation of growth rates of income per capita is incorrect.

In its present form, Unified Growth Theory is unacceptable. In order to improve it, it would be necessary to examine it closely to determine not only how much of it is based on the incorrect interpretation of data but also how much is just a pure fantasy. However, the best solution would probably be to replace it by a new theory.

Close analysis of Maddison's data (Maddison, 2010) opens new and fascinating avenues for the economic research. Rather than devoting time and financial resources on explaining features based on impressions and conjectures, we can focus our attention of explaining the features confirmed by the scientific analysis of data. In particular, the relevant and still unanswered questions are why the historical economic growth was hyperbolic, what mechanism should we use to explain this type of growth and why, relatively recently, the economic growth, global and regional, has been diverted to generally slower trajectories. Even the temporarily slightly boosted economic growth in Asia appears to be also a part of the generally-observed diversions to slower trajectories.

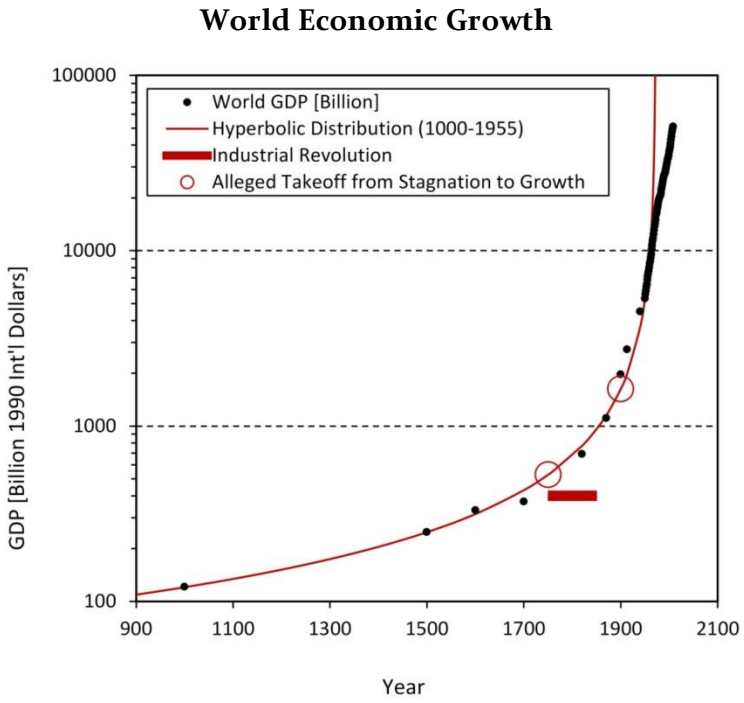

Figure 1. No takeoffs from stagnation to growth. Two postulated takeoffs are indicated (Galor, 2005a; 2008a; 2011; 2012a): for developed regions around 1750 and for less-developed regions around 1900. The world economic growth was not stagnant but hyperbolic and it was remarkably stable. Industrial Revolution, "the prime engine of economic growth" (Galor, 2005a, p. 212), had no impact on changing the economic growth trajectory. Unified Growth Theory (Galor, 2005a; 2008a; 2011; 2012a) is contradicted by data.

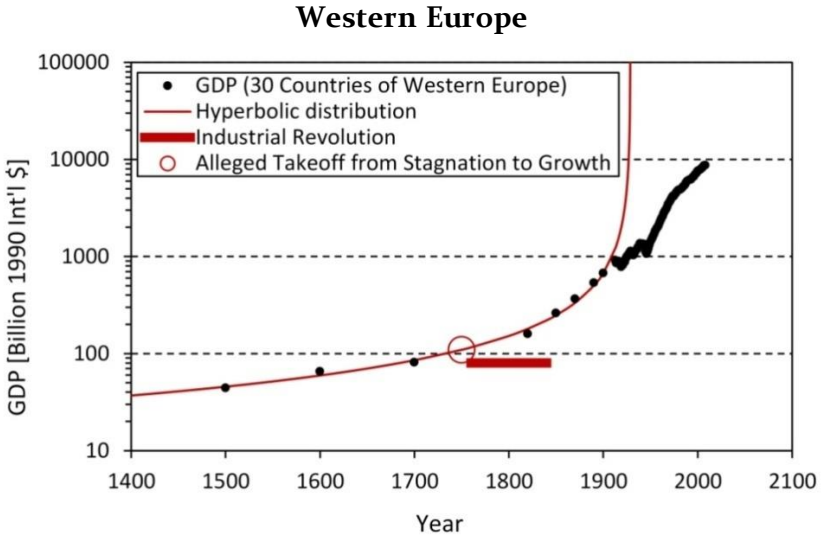

Figure 2. No takeoff from stagnation to growth. Economic growth in Western Europe was not stagnant but hyperbolic and it was remarkably stable. Industrial Revolution, "the prime engine of economic growth" (Galor, 2005a, p. 212), had no impact on changing the economic growth trajectory where this "engine" should have worked most efficiently. Unified Growth Theory (Galor, 2005a, 2008a, 2011, 2012a) is contradicted by data.

Eastern Europe

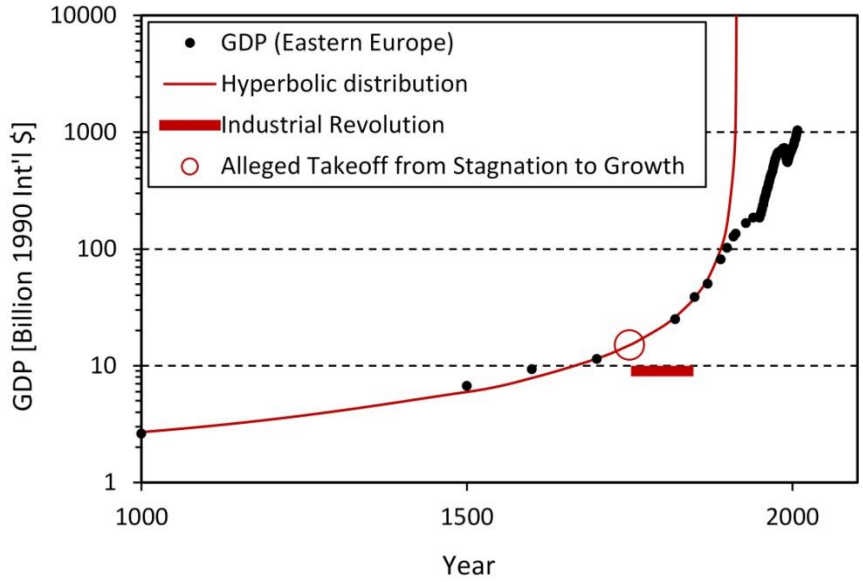

Figure 3.No takeoff from stagnation to growth. Economic growth in Eastern Europe was not stagnant but hyperbolic and it was remarkably stable. Industrial Revolution, "the prime engine of economic growth" (Galor, 2005a, p. 212), had no impact on changing the economic growth trajectory. Unified Growth Theory (Galor, 2005a; 2008a; 2011; 2012a) is contradicted by data.

Former USSR

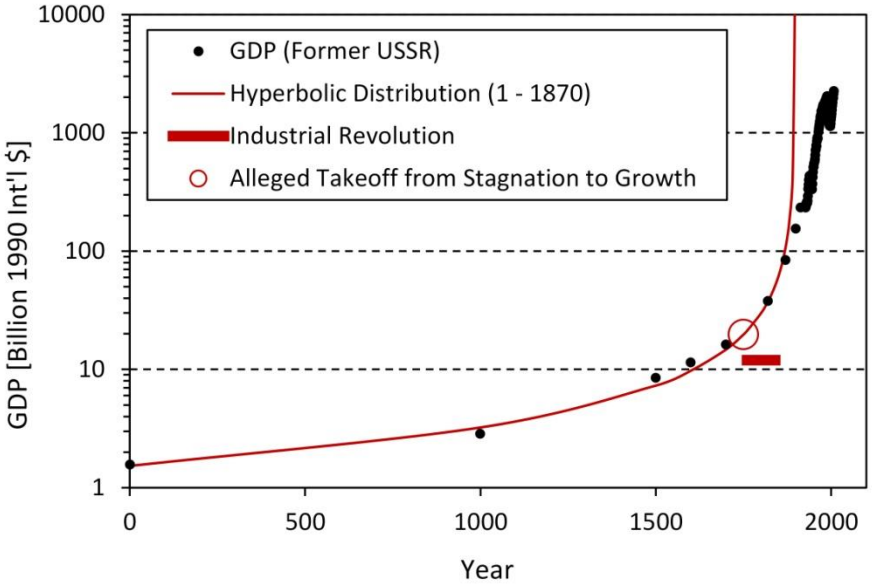

Figure 4. No takeoff from stagnation to growth. Economic growth in the former USSR was not stagnant but hyperbolic and it was remarkably stable. Industrial Revolution, "the prime engine of economic growth" (Galor, 2005a, p. 212), had no impact on changing the economic growth trajectory. Unified Growth Theory (Galor, 2005a; 2008a; 2011; 2012a) is contradicted by data.

Asia

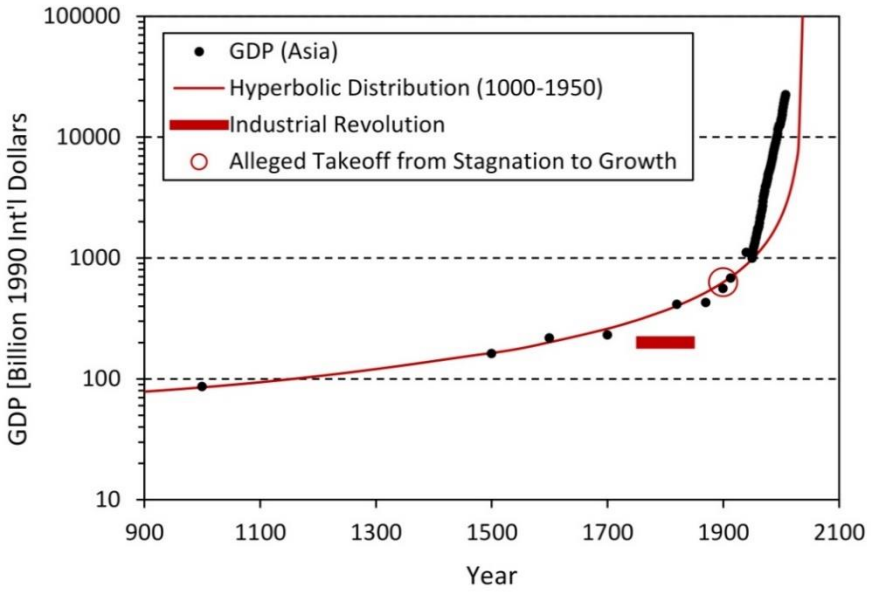

Figure 5. No takeoff from stagnation to growth. Economic growth in Asia was not stagnant but hyperbolic before the alleged takeoff and it was remarkably stable. The minor boosting after the alleged takeoff was not a transition from stagnation to growth but a transition from growth to growth. It was similar to the commonly-observed transitions to slower trajectories but in this case it was preceded by a minor and temporary boosting. Unified Growth Theory (Galor, 2005a; 2008a; 2011; 2012a) is contradicted by data.

Africa

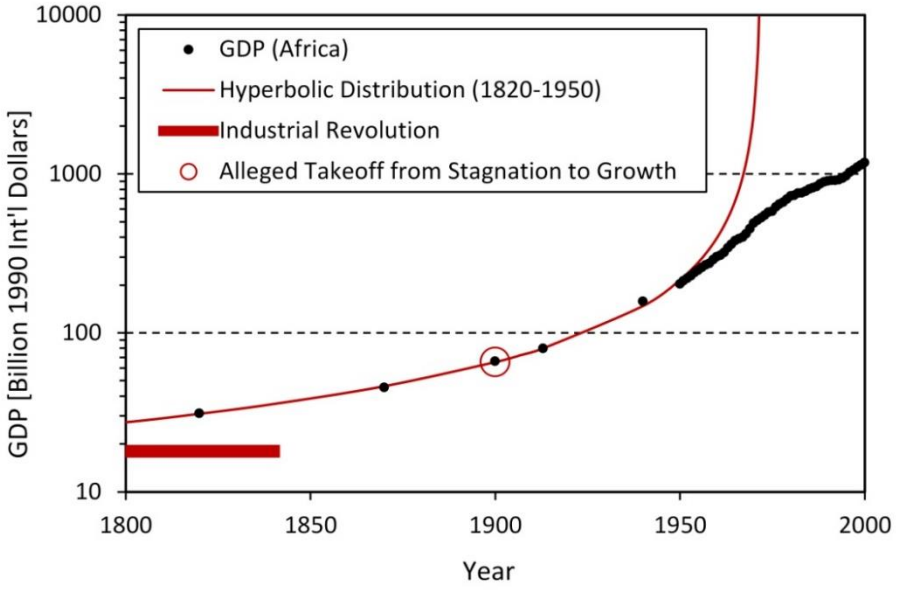

Figure 6. No takeoff from stagnation to growth. Economic growth in Africa was not stagnant but hyperbolic. Unified Growth Theory (Galor, 2005a, 2008a, 2011, 2012a) is contradicted by data. Shortly after the alleged dramatic but non-existent escape from the postulated Malthusian trap, economic growth in Africa started to be diverted to a slower trajectory.

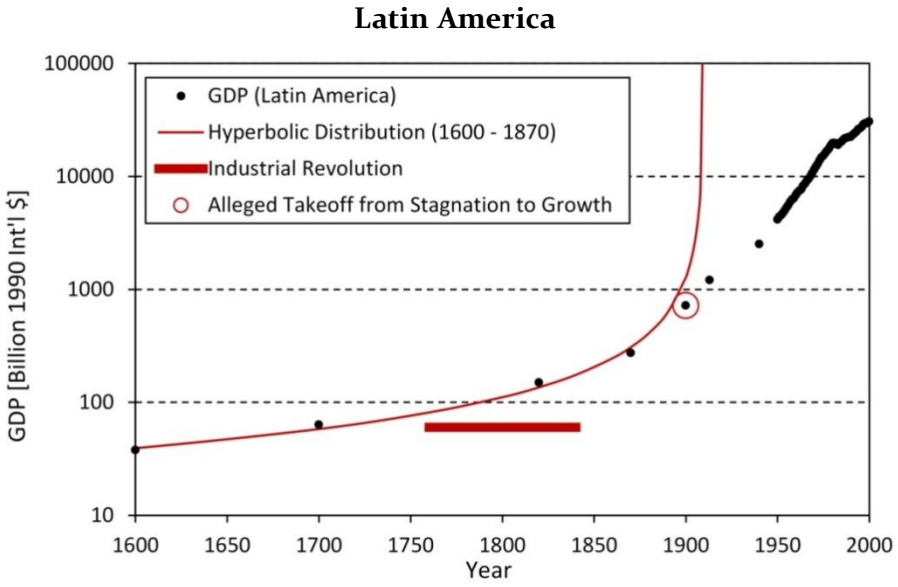

Figure 7. No takeoff from stagnation to growth. Economic growth in Latin America was not stagnant but hyperbolic. At the time of the alleged takeoff, economic growth in Latin America was already following a slower trajectory. The alleged takeoff is replaced by a slower growth. The "spectacular" or "stunning" escapes from Malthusian trap (Galor, 2005a, pp. 177, 220) never happened because there was no stagnation and no trap. Unified Growth Theory (Galor, 2005a; 2008a; 2011; 2012a) is contradicted by data.

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