



Phases of global demographic transition correlate with phases of the Great Divergence and Great Convergence



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ABSTRACT

The Great Divergence and, to a lesser extent, the Great Convergence phenomena have attracted considerable scholarly attention. However, the existing attempts at explaining these phenomena and their background share two significant drawbacks: first, no model (to the best of our knowledge) has managed to account for both the Great Divergence and the Great Convergence so as to explain the timing of the trend change (around 1970s). Second, most existing models concentrate heavily on the economic forces, frequently neglecting the demographic factor. We offer an approach to overcome these drawbacks, revealing a close coupling between phases of global demographic transition and phases of the Great Divergence and Great Convergence. As we account for the crucial role of the demographic component in these processes, we show that the timing of the trend change was not coincidental. Our findings suggest that the dynamics of global population growth and the Great Divergence and Great Convergence therefore may be considered so closely coupled as to be two sides of the same coin. On the other hand, they also suggest that the Great Divergence and Great Convergence should be treated as a single process, as two phases of the global modernization.

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1. Introduction

In the 19th century, northwestern Europe saw the birth of capital-intensive and fossil-fuel based manufacturing. Spreading throughout Europe and the United States, these changes triggered the explosive growth of a gap in per capita incomes between the First and Third World that has become known as the Great Divergence (see, e.g., Pomeranz, 2000; Goldstone, 2008, 2012; Clark, 2008; Allen, 2011). In the twentieth century, the Great Divergence peaked before the First World War and continued until the early 1970s, then, after two decades of indeterminate fluctuations, in the late 1980s it was replaced by the Great Convergence as the majority of Third World countries

reached economic growth rates significantly higher than those in most First World countries (e.g., Sala-i-Martin, 2006; Korotayev et al., 2011; Spence, 2011; Derviş, 2012).

The majority of the voluminous research on various aspects of the Great Divergence, taken as a whole, mainly focuses on five causes, such as geography, human capital, science and technology progress, cultural/political institutions, and international trade/colonies (for a substantial review see Goldstone, 2002, 2008, 2012; Chen, 2012). The cornerstone for the theory of convergence were laid by Alexander Gerschenkron (1952), who developed the ‘theory of relative backwardness’, stating that ‘the opportunities inherent in industrialization may be said to vary directly with backwardness of the country’ (Gerschenkron, 1952: 6), as well as by Robert M. Solow (1956), whose model accounted for the diminishing returns to capital and implied that in poor countries even small amounts of capital investment would substantially raise the productivity.

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Abel and Bernanke note that according to the Solow model, if the economy is open, the absolute convergence gets support of some additional economic forces. Since poorer countries have less capital per worker and therefore a higher marginal product of capital than the more affluent countries, investors from richer countries will be able to get greater profits by investing in poor countries. Therefore, foreign investment should provide a more rapid increase in capital stock in poor countries, even if the level of domestic savings in these countries is low (Abel and Bernanke, 2005: 234). It is easy to see that both the ‘Gershenkron’ factor and the ‘Solow’ factor of the faster growth of the peripheral (and especially semi-peripheral) economies are well mutually complementary, as the capital diffusion tends to be accompanied by technology diffusion (what is more, the capital diffusion is one of the main creators of the technology diffusion channels).

However, the existing attempts at explaining these phenomena and their background share two significant drawbacks: first, no model (to the best of our knowledge) has managed to account for both the Great Divergence and the Great Convergence so as to explain the timing of the trend change (around 1970s) (for our earlier attempt to account for this with a special mathematical model see Zinkina et al., 2014). Second, most existing models concentrate heavily on the economic forces, frequently neglecting the demographic factor. We offer an approach to overcome these drawbacks, revealing a close coupling between phases of global demographic transition and phases of the Great Divergence and Great Convergence. We show here that the dynamics of the size of the gap in GDP per capita between the First and Third Worlds corresponds to the dynamics of the growth rate of the world population (the specific countries we identify as composing the “First World” and “Third World” are listed in the Supplementary Information). We provide supporting evidence that this is not coincidental, and that the demographic component plays an important role in these processes.

2. Methods summary

GDP and population data were obtained from Maddison (2010) and the World Bank’s *World Development Indicators* Database (World Bank, 2014). First World countries comprised 30 Western European Countries, the USA, Canada, Australia, New Zealand, and Japan. GDP was totaled across these countries, and divided by total population to obtain First World GDP per capita. We designated as Second World countries the U.S.S.R. and its successor republics, Yugoslavia and its successor republics, and 5 eastern European countries. The Third World population and GDP were obtained by subtracting the sum of First World and Second World GDP and population from the World totals. Full specification of the country lists for First and Second worlds are given in the Supplementary Information.

Data was taken for the following years, to span the entire period 1–2012 AD, at points spaced to capture the movements of GDP/capita: AD 1, 1000, 1500, 1820, 1870, 1913, 1940, 1952, then every five years up through 2012. Full data is given in the Supplementary Information.

3. Parallel dynamics

The general dynamics of the gap in GDP per capita, shown as the ratio between the GDP/capita in the First and Third

Worlds from AD 1 to 2008, is presented in Fig. 1a. This curve can be seen to display a rather close similarity to the curve of the world’s population growth rate (shown here as the annual increase per thousand) presented in Fig. 1b. This similarity becomes especially salient when both curves are plotted in the same graph (Fig. 1c and d), and persists whether looking at the full span of two millennia or only at the two most recent centuries.

Regression analysis indicates that the correlation between the relative growth rates of the world population and the GDP per capita gap between the First and Third Worlds has a remarkably high value (see Fig. 2).

We are dealing here with a very tight correlation, accounting for 92% of all the variation. The match between the dynamics of world population growth, on the one hand, and the dynamics of the gap between the First and the Third World GDP per capita, on the other, looks especially salient in Fig. 3, where a logarithmic scale is used to facilitate the comparison across different scales.

The high correlation of the two time series is apparent. The significant acceleration of the world population growth rate observed in the 19th century (from 4.1‰ per year c. 1820 to 7.95‰ by 1870) corresponds to an explosively accelerated widening of the per capita income gap between the First and Third Worlds. During the period of 1870–1940 the deceleration of world population growth corresponded to a certain slowdown in the pace of the Great Divergence. Then, following the Second World War, a surge of acceleration of world population growth took place; and, as expected, it coincided with a renewed, corresponding acceleration of the global Divergence. Even a certain hitch in the acceleration of the world population growth rates that was observed in the 1950s was accompanied by a certain hitch in the Divergence speed. Both the gap between the First and Third World GDP per capita and the relative world population growth rate reached their peaks almost simultaneously (at 8.1 times for the gap and a rate of 20.65‰ per year for world population growth) in the late 1960s. There followed a decade in which the values of both variables declined, commencing the Great Convergence. However, in the late 1970s and early 1980s both the slowing-down of the world’s population growth rate and the decrease of the per capita income gap were interrupted (almost simultaneously). One could observe, throughout most of the 1980s, certain proportional, and mostly simultaneous, increases in both the per capita income divergence between the First and the Third World, and the world population growth rate. Then in the late 1980s there began a sharp and mostly steady (though not without certain hitches) decrease of both the GDP gap and the world population growth rate that has continued to the present day.

4. The income gap and world population growth as tightly-coupled processes

It could not be entirely ruled out, of course, that at least some of the consistency in this picture may be attributable to coincidence. However, the existence of a high correlation between the two time series can be explained. In truth, both of the global processes (the global demographic transition, otherwise known as the global demographic modernization, on the one hand, and the Great Divergence turning into the Great

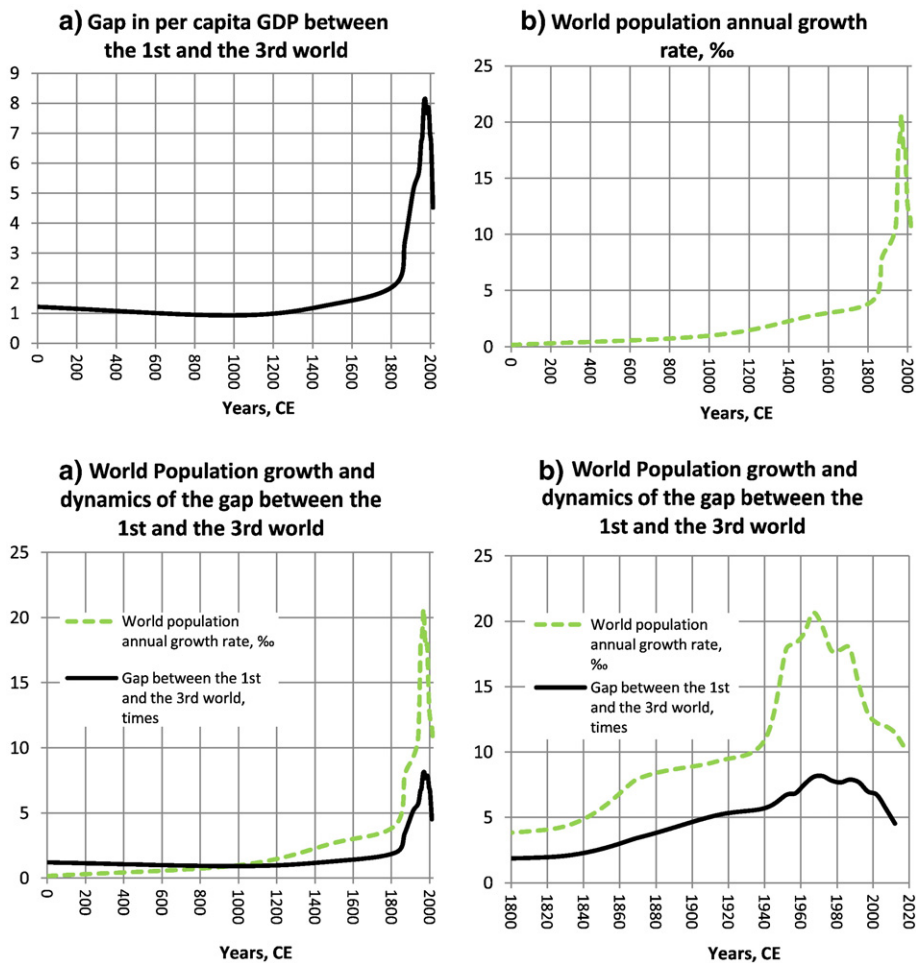


Fig. 1. Dynamics of the gap in GDP per capita and annual world population growth rates. In (a) the figures on the Y-axis denote by how many times the average GDP per capita in First World countries exceeded that in Third World countries for a given year. Thus, the value of 7 for 2000 means that in 2000 the GDP per capita was 7 times higher in the First World states than in the Third World countries. Note that a “gap” value of 1 means there is no difference between the groups. In (b) the Y-axis gives the global population growth rate in annual increase per thousand. Until 1940, the world population growth rate curve depicts the trend line and does not take into account cyclical and stochastic fluctuations (see Supplementary Information). In (d) we present a subset of data from (c) for the last 210 years.

Convergence, on the other) ought to be viewed as interrelated and showing two sides of one phase transition in the development of the World System – the global modernization (see Zinkina et al., 2014 for some more detail).

The explosive acceleration of the Great Divergence in the 19th century was quite naturally accompanied by a significant acceleration of the world population growth rate. The economic and technological modernization of the West, which propelled it to global leadership in labor productivity and per capita income, was then the major factor that determined the scope of divergence (e.g., Mokyr, 1990; Goldstone, 2002, 2008; Clark, 2008; Allen, 2009, 2011). At the same time, these positive developments in the West led to substantial improvements in the production, harvesting, storage, and transportation of food, and gains in public health and sanitation, resulting in increasing life expectancies and significantly declining mortality rates across all industrializing countries. In other words, the vast economic improvements brought about by the Industrial Revolution advanced the Western countries to the first phase of the demographic transition (e.g., Chesnais, 1992;

Caldwell et al., 2006; Dyson, 2010; Reher, 2011). In this phase, lasting throughout most of the 19th century in the industrializing countries, mortality declined sharply while fertility remained at a high level (e.g., Caldwell et al., 2006; Gould, 2009; Dyson, 2010; Reher, 2011; Livi-Bacci, 2012). The result was a rapid acceleration of population growth in the countries of the West, which was a very important factor in the acceleration of world population growth rates in the 19th century (Gould, 2009; Dyson, 2010; Reher, 2011; Livi-Bacci, 2012) (see Fig. 4).

From 1870 to 1920, most industrialized countries entered the second phase of the demographic transition, in which fertility began to decline and population growth slowed. This decelerated the growth of world population. The gap in GDP between the First and Third Worlds continued to grow, but more slowly. While in the First World slowing population growth and continued economic development led to ever-higher per capita GDP, the Third World also began to benefit from the rapid growth in international trade and the diffusion of railroads and international investment.

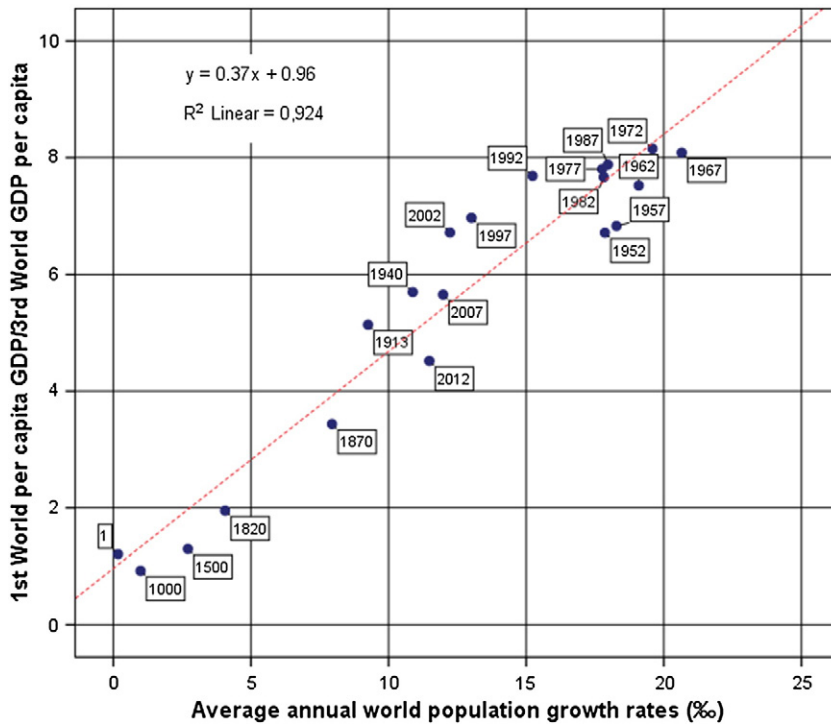


Fig. 2. Correlation between the gap in GDP per capita between the First and Third Worlds and the growth rate of world population (%). Note that the value of constant α in the regression model $y = \alpha + \beta x$ in our case equals $0.96 \approx 1$. Incidentally, this suggests that when the world population stabilizes (that is, when the global modernization phase transition is completed), the gap between the First and the Third World may almost disappear (data in Supplementary Information).

In the period after the Second World War, the acceleration of world population growth and the increase in the speed of Divergence were also rather strongly interconnected. At this later phase of global modernization, the main contribution to

the acceleration of world population growth was made by the entrance of the majority of the Third World countries (where the overwhelming majority of the world population lived) into the first phase of the demographic transition (e.g., Caldwell

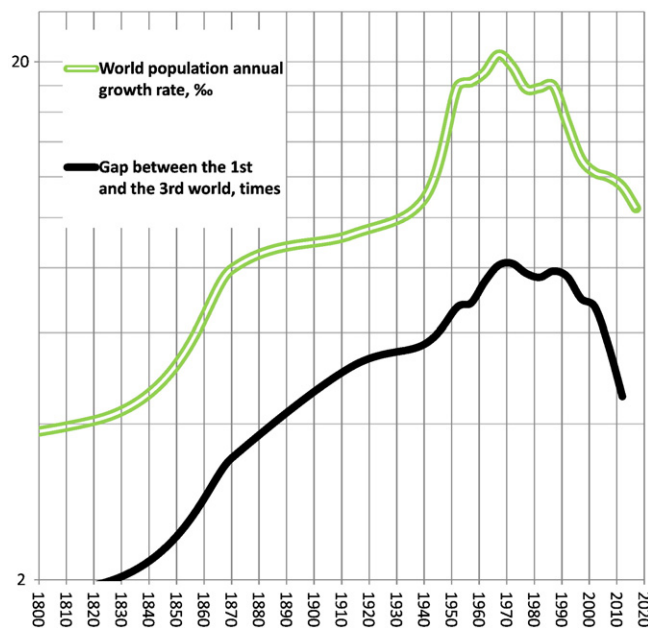


Fig. 3. The gap in GDP per capita between the First and the Third World, 1–2008 and the growth rate of world population (%), logarithmic scale. Note that this is the same data as in Fig. 1d just on log scale, and that a constant gap between the two curves represents a constant factor (i.e., the 0.37 found from the regression) between them.

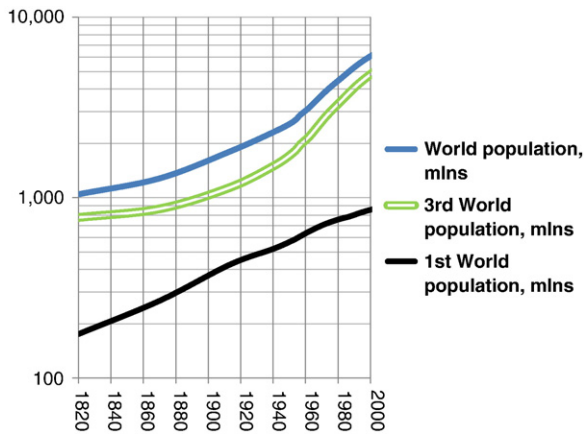


Fig. 4. The total world population growth against the background of population dynamics of the First and Third Worlds, millions, logarithmic scale.

et al., 2006; Gould, 2009; Dyson, 2010; Reher, 2011; Livi-Bacci, 2012). It is of note that in most cases the demographic transition in the developing world was not as much connected to radical increases in economic growth rates (as was observed in the Western countries during the prior period), but predominantly arose from the diffusion of healthcare technologies that caused a very rapid decline of infant and child mortality (from 350+‰ to 35‰ or less). Thus, Preston (1975, 1980) reveals in his classical works that the spectacular life expectancy growth observed in the developing countries in 1940–1970 was only 15–25% due to improvements in nutrition, income, and other living standards indicators, while 50–80% of this growth was stipulated by the diffusion of medicine and health care technologies. The drop in mortality associated with the Third World's first phase of the demographic transition was therefore even more rapid than that which occurred in the First World; combined with still high fertility the result was a dramatic acceleration of world population growth.

The resulting population growth in the Third World was more rapid than any seen in world history; growth rates of 30% or even 40% pushed world population growth rates to new highs. However, such rapid growth rates also held down the growth of per capita incomes in developing countries relative to the rapid gains being made in the First World in the decades after WWII (even though the First World also experienced a brief surge in population growth rates after the War). It was only when Third World countries also began to limit fertility, entering their second phase of the demographic transition, that their per capita GDP growth sharply accelerated to levels above those of the First World. With this transition, world population growth began to drop sharply, as did the income gap; we have since been seeing the Great Convergence.

The crucial role of population dynamics in driving GDP/capita in this phase can be seen in the fact that overall GDP growth rates in the Third World were already roughly as high as those in the First World in the 1950s and 1960s, as shown in Fig. 5. However, in the Third World this growth arose against the background of a demographic explosion (that is very characteristic for the first phase of the demographic transition [see, e.g., Chesnais, 1992; Caldwell et al., 2006; Dyson, 2010; Reher, 2011; Livi-Bacci, 2012]), whereas First World countries

were by then in the second phase of the demographic transition and experiencing rather slower population growth. From 1950 to 1970 the population of Third World countries increased by 56%, more than twice as much as that of First World countries, which grew by only 24% in this period. As a result, during the 1950s and 1960s the gap between the First and Third Worlds in per capita GDP increased substantially despite the fact that overall GDP growth rates in the developed and developing countries were almost identical in those years.

Hence, the close coupling between economic and demographic dynamics in both of these phases of global modernization is clear. However, it differed rather significantly as regards its contents and direction across the periods. In the West of the 19th century it was per capita GDP that served as the main independent variable whose growth then led to the decrease of mortality and the acceleration of the population growth, whereas in the postwar Third World it was the population growth rate that led; the initial acceleration of population growth initially held back per capita GDP growth, but the deceleration of population growth then produced a demographic dividend (more workers and fewer dependents) that helped produce much higher GDP growth rates.

Our last figure demonstrates how closely the economic and demographic dynamics were linked. The peak of the gap in GDP per capita in the late 1960s also coincided with the absolute minimum in the share of the working-age population in the total population in Third World countries (UN Population Division, 2014). It was precisely when the impact of falling fertility started to produce a rising percentage of workers – the 'demographic dividend' – in developing nations (e.g., Bloom et al., 2001; Bloom and Sevilla, 2002; Mason, 2001, 2007; Hawksworth and Cookson, 2008: 7–10) that the income gap with the First World started to decline (see Fig. 6).

Therefore, we can argue that the peak in the income gap between the First and Third World occurring with almost perfect accuracy at the same time as the peak in world population growth rates is no coincidence. It is because the onset of the great Convergence depended on a slow-down in growth rates in the Third World that decelerated world population growth.

5. Conclusion

Our research shows that throughout the modern era the gap between First and Third World incomes has been very strongly influenced by the timing of their entry into the first and second phases of the demographic transition. We would not say that the dynamics of the Great Divergence and Great Convergence are determined entirely by the dynamics of the global demographic transition. The onset of the modernization process, including the reorganization of politics, the economy, and social life, was due to many factors (see, e.g., Mokyr, 1990; Barro, 1991; Sachs et al., 1995; Sala-i-Martin, 1996; Quah, 1996; Lee et al., 1997; Pomeranz, 2000; Yifu Lin, 2003; Allen, 2009, 2011; Clark, 2008; Korotayev et al., 2011; Spence, 2011; Goldstone, 2002, 2008, 2012). However, we are quite ready to claim that, once begun, the impact of modernization on incomes was strongly dependent on the timing of the phases of the demographic transition in different regions. The dynamics of global population growth and the Great Divergence and Great Convergence therefore may be considered so closely

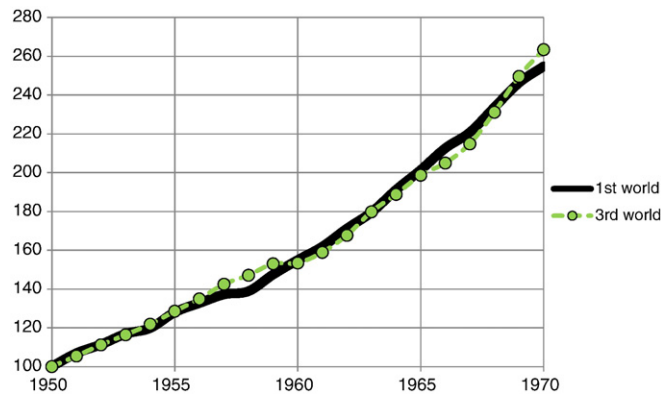


Fig. 5. Relative GDP dynamics of the First and Third Worlds 1950–1970, 100 = 1950 level.

coupled as to be two sides of the same coin. On the other hand, our findings suggest that the Great Divergence and Great Convergence should be treated as a single process, as two phases of the global modernization. Potential further research in this direction may imply the analysis of the Great Divergence and Great Convergence as phases of the global modernization, which may help to find the deep underlying causes of the detected synchronization, to forecast if the detected correlation will continue, or to detect the “physical sense” of the 0.37 factor found by the regression analysis of the dataset in Fig. 2.

In conclusion, let us summarize our answer to the following question: “Was underdevelopment a cause or an effect of the fast population growth?” It is important to stress that we are dealing in our case with a truly dynamic relationship between the two variables in question, which implies the absence of any simple answer to such a question. Actually, the casual direction of this relationship was rather different at different phases of the global modernization transition. In the 19th century the modernization of the West led both to the fast acceleration of its economic growth (against whose background the “Rest” started to look “underdeveloped”), and to the explosive growth of the population of the West (and, hence, to a substantial increase in the world population growth rates) through the decrease of the mortality rates in the West (caused ultimately just by the economic modernization of the West

and acceleration of its economic growth). After the Second World War the casual link appears to have been the opposite. In the first decades after the war, in most cases the demographic transition in the developing world was not as much connected to radical increases in the GDP per capita growth rates (as was observed in the Western countries during the prior period), but predominantly arose from the diffusion of healthcare technologies that caused a very rapid decline of infant and child mortality. In this period the population explosion in the Third World resulted in the situation when both the world population growth rates reaching and the gap between the First and the Third World reaching their maximum levels (though the GDP growth rates in the 1950s and the 1960 were approximately the same in the First and Third World, the explosive growth of the population of the developing countries against the background of the declining population growth rates in the developed countries led to the further increase in the gap between them as regards per capita incomes). On the other hand, the entering of the majority of the Third World countries into the second phase of the demographic transition (implying the radical decline of the fertility rates) contributed in a rather significant way both to the start of the decline of the world population growth rates and the onset of the Great Convergence (that implies the shrinking of the gap between the First and Third Worlds as regards per capita GDP values). However, at all phases of the global modernization transition the link between the two variables in question remained rather strong that results in a rather strong correlation between them that we have detected.

Contributions

A.K. initiated the project. All authors contributed to the final version of the paper.

Competing financial interests

The authors declare no competing financial interests.

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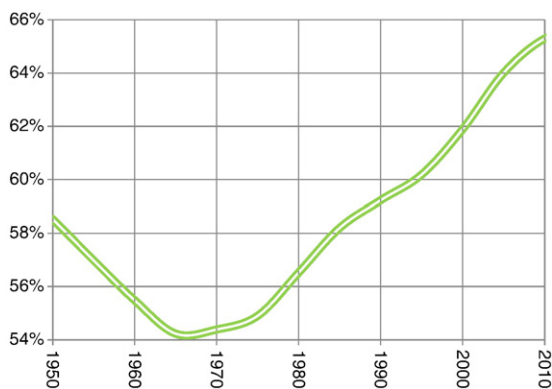


Fig. 6. Dynamics of the percentage of the Third World population that is in the working age range (15–65 years old), 1950–2010.

Appendix A. Supplementary information

Supplementary data to this article can be found online at <http://dx.doi.org/10.1016/j.techfore.2015.01.017>.

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