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# Ahmet Şık’s Defence Statement On The Trial Of Cumhuriyet 24 July

# 2017

I will start with a quote from the prologue of my book “We walked parallel on these roads”, published in 2014, three years ago. The foreword of this review-research book explaining how the mafia-governing coalition between the AKP and the Gülen community is dispersed begins as follows: “The AKP and Gulen congregation, two forces that turn Turkey into political and social coexistence and continued together with the support of partisans, so-called powerhouse, sewage exploded. The two forces that built the so-called ‘New Turkey’, a Machiavellian understanding that is appropriate to apply any kind of rush to achieve it, AKP and Gulen Congregation split.

Both do not want the democratization of the system and society, they are the foci of power that seeking to conquer the state, they are trying to organize it by making their authority predominant.

These two foci, with an understanding of trying to make the commitment to the authority of the state, which they think they will be the only power to speak in the long run, have accumulated material for destroying each other while fighting common enemies on the other hand.

The closeness of the day that these materials could be used was apparent from the fact that the stench in the drainage was spreading out over for a long period of time. Threats from media columns, underhanded liquidations, occasionally leaked phone calls, and police-judicial operations based on illegality were the signs that they would be targeted at the constituents of the government after common enemies.

When they were convinced that there were no enemies to be destroyed, they were aiming at each other by holding onto the fight that the state’s owner would be. Yes, it was a mess and still it is a mess. Apparently it will be like this for a while. In this battle where ethics and religion are used, the lies that meet the needs of the parties are more prevalent than the truths. So, do not be fooled by the defenses made by them. This war is not for democracy and clean society, nor for peace or civilization as somebody claimed. They just fight for being the owner of the state.

After these lines were published, the war between the AKP and the Gülen congregation worsened. The period of a false history writing process, which started with the Ergenekon investigations in 2007, who took more share on the plundering of the state and the country by the ruling and crime partners, extended to a coup attempt. On 15th July 2016, 250 people were killed in a bloody upheaval.

There is serious doubt that this attempt, which we are forced to believe is the sole responsibility of the Gülen Community, was already known by the government. Despite the fact that over a year has passed and numerous investigations have been launched, suspicions have increased rather than decreased. The July 15 coup d'etat, which is required to remain in the dark with many signs, which led us to believe that the needed 'Controlled Chaos' was being yielded, was the most important milestone of the fake historiography that spanned the last 10 years.

The only truth of this fakeness which has been constructed with the words "democratization-civilization" and lies, is the people slaughtered by the coup plotters.

It is worth to ask questions about what is wanted to be left in the dark and saying "Controlled Chaos" to this situation. Recep Tayyip Erdogan, who is the target of the coup attempt, has spilled the beans by expressing his intention while the country was in the middle of a bloodshed, and said "This coup is a blessing from God to us". We have seen what 'blessing' means and have witnessed it together and are still witnessing it. We pass through the dark and increasingly darker days, where those who voiced the truth, those who objected to the crime order, those who demanded their usurped rights, are the voices being muted and strangled.

Read more: http://www.pen-international.org/ahmet-siks-defence-statement-on-the-trial-of-cumhuriyet-24-july-2017/

# Zygmunt Bauman: Liquid Modernity Revisited

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# Financial Globalization Can Wreck Societies And The World Economy: An Interview With Political

# Economist Gerald Epstein


Prof.dr. Gerald Epstein

Since the outbreak of the 'global financial crisis' of 2008, there has been an explosion of interest in finance capital and on the so-called 'financialization' of the economy. Yet, there is no general consensus among scholars either on the causes behind the rise of finance capital or on the actual impact of 'financialization' on the economy and society. One of the leading scholars in the field of political economy interested in the 'financialization' of the economy and on the links between neoliberalism, globalization and 'financialization' is Gerald Epstein, Professor of Economics and Co-Director of the Political Economy Research Institute (PERI) at the University of Massachusetts at Amherst. In the interview below, Professor Epstein addresses several issues related to 'financialization', including it's macroeconomics and impact on the world economy, as well as it's links to instability and capitalist crises.

*J. Polychroniou and Marcus Rolle: Professor Epstein, an increasing number of scholars have been turning their attention since the outbreak of the 'global financial crisis' of 2008 to the role of the finance sector in advanced capitalist economies. Can you give us a sense of how we should proceed to understand 'financialization', and address the question on whether it represents a distinct 'phase' in the evolution of capitalism?*

*Gerald Epstein:* 'Financialization' is the latest, and probably most widely used term by analysts trying to 'name' and understand the contemporary rise of finance and its powerful role. The term had been developed long before the crisis of 2008 but, understandably, since the crisis hit, it has become even more popular. This vast and rapidly expanding literature on financialization has a number of important strands. Some of the literature focuses on clarifying the definition of financialization, and assessing whether it is a dominant cause of the ills confronting capitalism or is just a symptom of other, deeper causes; some asks whether financialization is a new ‘phase: of capitalist development, perhaps a new ‘mode of accumulation’, or considers whether it is just one among a number of important developments along with ‘neo-liberalism’, ‘digitization’ and ‘globalization’ that are arising in the contemporary world; other literature is focused on less theoretical and more empirical matters, trying to measure the nature and extent of financialization, however defined, and to describe its institutional and economic dimensions; and still other work is focused on attempting to analyze theoretically and empirically the impact of financialization on important phenomena such as financial crises, productive investment, productivity growth, wages and income distribution; and finally, other parts of the literature are more policy-oriented, trying to grapple with policies and structural changes than can improve the role that finance plays in the economy. There are still many conundrums and open questions about ‘financialization’ which means it will remain a fruitful area for multi-disciplinary research and an important arena for political battles and structural reform for the foreseeable future.

As discussed by Malcolm Sawyer, the term financialization goes back at least to the 1990’s and probably was originated by Republican political operative and iconoclastic writer Kevin Phillips, who first used the term in his book *Boiling Point* (New York: Random House, 1993) and, a year later, used the term extensively in his *Arrogant Capital* in a chapter entitled the “Financialization of America”. Phillips defined *financialization as* “a prolonged split between the divergent real and financial economies (New York: Little, Brown and Co., 1994). (Sawyer, 2013, pp. 5-6).

Scholars have adopted the term, but have proposed numerous other definitions. Sociologist, Greta Krippner, for one, gives an excellent discussion of the history of the term and the pros and cons of various definitions. As she summarizes the discussion, some writers use the term ‘financialization’ to mean the ascendancy of “shareholder value” as a mode of corporate governance; some use it to refer to the growing dominance of capital market financial systems over bank-based financial systems; some follow Hilferding’s lead and use the term financialization to refer to the increasing political and economic power of a particular class segment, the rentier class; for some financialization represents the explosion of financial trading with myriad new financial instruments; finally, for Krippner herself, the term refers to a "pattern of accumulation in which profit making occurs increasingly through financial channels rather than through trade and commodity production". (Greta Krippner, 'Thought Financialization of the American Economy,' Socio-Economic Review 3 (2), 2005, p. 174).

I have defined the term quite broadly and generally as: "the increasing role of financial motives, financial markets, financial actors and financial institutions in the operation of the domestic and international economies." (Gerald Epstein, ed., Financialization and the World Economy. Northampton, MA: Edward Elgar Publishers, 2005). This definition focuses on financialization as a process, and is quite agnostic on the issue of whether it constitutes a new mode of accumulation or broadly characterizes an entire new phase of capitalism. Broad definitions like mine have the advantage of incorporating many features, but have the disadvantage, perhaps, of lacking specificity.

Other analysts have used variations on the term financialization to refer to more or less the same set of phenomena. Tom Palley has used the term 'neo-liberal financializaton' in his writings to emphasize the importance of neo-liberalism as part and parcel of the rise of financialization (Palley, 2013a, p. 8) Eckhard Hein and Tom Palley have not referred to financialization but to 'finance-dominated capitalism'.

Another important debate is on the periodization of 'financialization'. Is it only a recent phenomenon, say, important since the 1980's? Or does it go back at least 5000 years, as Malcolm Sawyer has suggested? If it goes back a long time, does it come in waves, perhaps linked with broader waves of production, commerce and technology or is it a relatively independent process driven by government policy such as the degree of financial regulation or liberalization? Giovanni Arrighi famously argued that over the course of capitalist history, financialization tends to become a dominant force when the productive economy is in decline, and when the dominant global power (or "hegemon") is in retreat. Think, for example the early 20th century when Great Britain was losing power relative to Germany and the US, and the UK economy was stagnating. This was a period also of a great increase in financial speculation and instability.

In this way of thinking, financialization represents a new phase of capitalism, perhaps one that signals a decline in the power of the hegemonic country, in this case, the United States.

I hesitate to make such a sweeping claim. I think it is clear that financialization is a highly important phenomenon that is having big impacts on our economy. Does it define our epoch? This is a crowded stage. Financialization can cause massive problems but, unlike climate change, it is not likely to destroy the planet.

*Polychroniou and Rolle: To what extent can we speak of the macroeconomics of financialization? In other words, how does financialization impact on investment, consumption, and distribution?*

*Gerald Epstein:* There has been important research on the macroeconomics of financialization. Eckhard Hein and Til Van Treeck from Berlin, Tom Palley of the US and Englebert Stockhammer from the UK have been among the forerunners in this research area. These researchers identify three key channels through which financialization can affect macro variables and outcomes: 1) The objectives of firms and the restrictions that finance places on firm behavior; 2) New opportunities for households' wealth-based and debt-financed consumption; and 3) The distribution of income and wealth between capital and labour, on the one hand, and between management and workers on the other hand.

The net effect of these factors can mean that financialization can lead to economic expansion or stagnation dependeing on the relative size of these factors. But it almost always increases inequality. In addition, it almost always leads to financial instability and even crises.

Empricial work has looked at more specific impacts. Much of the macroeconomic literature on financialization concerns, of course, the impact of financialization on crucial macroeconomic outcomes such as economic growth, investment, productivity growth, employment, stability and income distribution. Stockhammer pioneered the theoretical analysis of the impact of financialized manager motives on investment. He showed that finance oriented management might choose to undertake lower investment levels than managers with less financialized orientations. Ozghu Orhangazi used firm level data to study the impact of financialisation on real capital accumulation in the United States. He used data from a sample of non-financial corporations from 1973 to 2003, and finds a negative relationship between real investment and financialisation.

Leila Davis provided further evidence of negative impact of financialization on real investment. Her results are consistent with the concerns expressed by heterodox analysts and others that financialization will tend to reduce real investment.

An increasing chorus of analysts have expressed concerns that ‘short-termism’ associated with financialization may be coming at the expense of investments in human capital, research and development, employment and productivity growth. In a set of surveys of corporate managers, economists have shown that many chief financial officers are willing to sacrifice longer term investments in research and development and hold on to value employees in order to meet short-term earnings per share targets. Other empirical studies show that managers are willing to trade-off investments and employment for stock repurchases that allow them to meet earnings per share forecasts. Eileen Appelbaum and Rosemary Batt find in a survey of econometric studies of private equity firms find that especially large firms that use financial engineering to extract value from target companies, have a negative impact on investment, employment and research and development in these companies. In short, there is significant empirical evidence that ‘short-termism’ and other aspects of financial orientation have negative impacts on workers well-being, productivity and longer-term growth.

This raises the issue of the over-all impact of financialization on income distribution. There has been some empirical work to look at the impact of financialization on income and wealth distribution. Descriptive analysis in the U.S. indicates that the top earners, the 1% or even .01% of the income distribution get the bulk of their incomes from CEO pay or from finance.

There has also been interesting research on the relationship between financialization and economic growth. As the massive recession stemming from the great financial crisis makes clear, there is no linear relationship between the size and complexity of financial markets and economic growth. Several econometric studies have suggested an inverted U shaped relationship between the size of the financial sector and economic growth. A larger financial sector raises the rate of economic growth up to a point, but when the financial sector gets too large relative to the size of the economy, economic growth begins to decline. To the extent that this relationship is true, economists are still searching for the explanation. One argument is that as the financial sector increases in size, because of its relatively high pay levels, it pulls talented and highly educated employees away from other sectors that might contribute more to economic growth and productivity. As a University Professor teaching economics since the 1980’s, I can verify that many of my undergraduate students had the dream of going to work on Wall Street. Perhaps some of them could have contributed more elsewhere.

Adding up all these factors in the case of the United States, Juan Montecino and I estimated that, at the margin, the US financial sector in its current configuration has had a net *negative* on the US economy. We estimate that it has cost the US economy as much as $22 trillion over a thirty year period. (See, The Roosevelt Institute *Overcharged: The High Cost of High Finance* .

*Polychroniou and Rolle: Neoliberalism, globalization and ‘financialization’ have shaped much of the world economy since the early 1980s. Is ‘financialization’ directly linked to globalization?*

*Gerald Epstein:* Yes, definitely. In fact, modern globalization has, as one of its key components, a massive amount and increase in the level of financial transactions of all kinds. To take one stark measure, according to the Bank for International Settlements (BIS), there were $5.1 TRILLION in foreign exchange trades PER DAY in 2016, compared with only $80 BILLION of trades in goods and services per day. In short, there are more than $6 of foreign exchange trading for every $1 of foreign trade. What’s being done with all this foreign exchange trading? Presumably the buying and selling for foreign financial assets and liabilities — much of this for speculation. The interconnection financialization and globalization in this sense is so intertwined that for years, mainstream economists and some policy makers have been referring to the current era in financial economic relations as one of “financial globalization” – even before the term ‘financialization’ became popular. Another clear sign of the global nature of ‘financialization’ comes from the international nature of financial crises in recent decades, the most recent one being the great financial crisis of 2008. In this case, European banks in particular were greatly implicated in the deals that led up to the crisis, and a number of them are still paying the price.

However, it is not just the international banks that are involved in global aspects of financialization. Much of global investment by multinational corporations (MNC’s) have highly financialized components to them. The New School’s Will Milberg and his co-author, Debora Winkler, have written a terrific book called

"Outsourcing Economics" that describes the financial activities of MNC's. They argue that these financial activities can sometimes support real investment that creates jobs and enhances productivity, but that much of it can also be engaged in other, less productive activities, such as tax evasion through the purchasing of financial assets or other financial dealings, and also various forms of financial speculation. *Citizens for Tax Justice* and authors like Nicholas Shaxson in *Treasure Islands; Uncovering the Damage of Offshore Banking and Tax Havens*, and James Henry who has written widely on global aspects of the financial underground.

*Polychroniou and Rolle: According to the literature, there have been numerous financial crises from the late 1970s onwards, more than any other time in the history of capitalism, with the financial crisis of 2008 having by far the most destabilizing effects. In your view, what makes financialization such a destabilizing force?*

*Gerald Epstein:* For centuries, finance and banking have been associated with financial crises, both domestic and international. The late, great economic historian Charles Kindleberger wrote in his famous book *Manias, Panics and Crashes*, that international financial crises are a "hardy perennial". Going back to the 16th century, Kindleberger estimated that a financial crisis happened someplace in the world once every 7 years on average.

Finance is inherently de-stabilizing because it is based on a promise about the future that can be reneged on, or just plain mis-calculated, since, as Keynes reminded us, the future is highly uncertain. And finance can easily lead to a whole chain of fragile interconnections through the economy which can come down like a house of cards. Now this would not matter much if finance wasn't important to the operations of modern economies, but it is. And this is especially true of "financialized economies"….in financialized economies, finance has become more and more central to the operations of the economy….finance has insinuated itself into almost every nook and cranny, and so, when something goes wrong, the vulnerability can spread and wreck havoc. And I am not talking only about instability and crises, but also about destructive aspects of the everyday operations of the economy.

Interestingly, economists Carmen Reinhart and Kenneth Rogoff showed in their book *This Time is Different: Eight Centuries of Financial Folly,* this cycle was interrupted in the first 35 years or so after the Second World War, when there were virtually no financial crisis anywhere in the world. Why was this the case? The reason was that private finance, and especially global private finance, played a relatively small role in the period 1945-1980. This is because public finance was so important, because financial regulations were so stringent, and also because private finance had crashed so badly in the 1930's and it took decades for it to recover.

The financial de-regulation pushed by the bankers and their allies in the decades following the second world war eventually succeded and for the last several decades we have been back in the world of the "hardy perennial" financial crisis.

*Polychroniou and Rolle: Is a return to the era of industrial capitalism as a means of countering the destructive effects of financialization a realistic policy that progressives should embrace?*

*Gerald Epstein:* I think the impulse to bring finance under social control and reduce its role and destructive economic and political behaviors is absolutely correct and must be accomplished if we are going to make significant progress on reigning in financial instability and other destructive financial practices. To do this we need to not only re-regulate finance, but also need to develop and spread more public options in finance, what I have called 'finance without financiers' – more 'stakeholder financial institutions' — banks, savings institutions, insurance providers that are controlled by stakeholders and not shareholders.

Now that doesn't necessarily mean that these set of financial initiatives ought to be accompanied by more 'industrial' activities as our salvation. This is a very complex question that I cannot pretend to answer, especially in a short interview. But suffice it to point out the obvious problem that we are faced with an existential threat of climate change. This means that our economic alternatives must confront this problem. As my colleague Robert Pollin and his colleagues have shown, a significant push in the US and elsewhere toward the production of renewable energy and energy conservation can have many collorary benefits, including job creation and reduction in income inequality. It is these initiatives that a reformed and revitalized finance can help to promote and that we should focus on, especially in the US and other rich countries.

*Polychroniou and Rolle: Quite a few people argue that another financial crisis will* *surely erupt in the near future, especially with Donald Trump advocating deregulation. In this context, what signs in the economy should we be looking for in order to predict the next financial crisis?*

*Gerald Epstein:* While it is true that no two financial crises are ever exactly the same, and that massive crises like the one we had in the 1930's and then again in 2007-2008 are infrequent, there are, nonetheless a few common signs to watch out for:

First, massive increases in private debt in relation to the size of the economy. High levels and large increases in 'leverage' as this debt ratio is called, has been shown to be one clear sign of financial vulnerability.

Second, big asset bubbles, such as we saw in the housing market in 2004-2007, or that we saw in the U.S. stock market in the 1920's, or in tulips in Amsterdam in the 17th century – these can be very dangerous because they are usually fed by massive increases in debt – the first point above – which leads to dangerous interconnections and the building of a financial house of cards.

Finally, complacency. The idea that 'this time is different' — the idea, that is, that we have reached a 'new age' such that bubbles and massive increases in private debt aren't dangerous this time because of some new invention or strategy….these self-delusional ideas are always present in the build up to crisis, and are always wrong.

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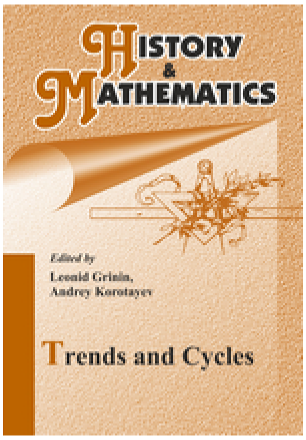
# Biosocial Evolution, Ecological Aspects, And Consciousness ~

# Modeling Of Biological And Social Phases Of Big History



*Abstract*
In the first part of this article we survey general similarities and differences between biological and social macroevolution. In the second (and main) part, we consider a concrete mathematical model capable of describing important features of both biological and social macroevolution. In mathematical models of historical macrodynamics, a hyperbolic pattern of world population growth arises from non-linear, second-order positive feedback between demographic growth and technological development. Based on diverse paleontological data and an analogy with macrosociological models, we suggest that the hyperbolic character of biodiversity growth can be similarly accounted for by non-linear, second-order positive feedback between diversity growth and the complexity of community structure. We discuss how such positive feedback mechanisms can be modelled mathematically. ~ *This research has been supported by the Russian Science Foundation (Project No 14-11-00634).*

Keywords: *social evolution, biological evolution, mathematical model, biodiversity, population growth, positive feedback, hyperbolic growth.*

*Introduction*
The present article represents an attempt to move further in our research on the similarities and differences between social and biological evolution (see Grinin, Markov, and Korotayev 2008, 2009a, 2009b, 2011, 2012). We have endeavored to make a systematic comparison between biological and social evolution at different levels of analysis and in various aspects. We have formulated a considerable number of general principles and rules of evolution, and worked to develop a common terminology to describe some key processes in biological and social evolution. In particular, we have introduced the notion of ‘social aromorphosis’ to describe the process of widely diffused social innovation that enhances the complexity, adaptability, integrity, and interconnectedness of a society or social system (Grinin, Markov, and Korotayev 2008, 2009a, 2009b). This work has convinced us that it might be possible to find mathematical models that can

describe important features of both biological and social macroevolution. In the first part of this article we survey general similarities and differences between the two types of macroevolution. In the second (and main) part, we consider a concrete mathematical model that we deem capable of describing important features of both biological and social macroevolution.

The comparison of biological and social evolution is an important but (unfortunately) understudied subject. Students of culture still vigorously debate the applicability of Darwinian evolutionary theory to social/cultural evolution. Unfortunately, the result is largely a polarization of views. On the one hand, there is a total rejection of Darwin's theory of social evolution (see, *e.g.*, Hallpike 1986). On the other hand, there are arguments that cultural evolution demonstrates all of the key characteristics of Darwinian evolution (Mesoudi *et al.* 2006).

We believe that, instead of following the outdated objectivist principle of 'either – or', we should concentrate on the search for methods that could allow us to apply the achievements of evolutionary biology to understanding social evolution and *vice versa*. In other words, we should search for productive generalizations and analogies for the analysis of evolutionary mechanisms in both contexts. The Universal Evolution approach aims for the inclusion of all mega-evolution within a single paradigm (discussed in Grinin, Carneiro, *et al.* 2011). Thus, this approach provides an effective means by which to address the above-mentioned task.

It is not only systems that evolve, but also mechanisms of evolution (see Grinin, Markov, and Korotayev 2008). Each sequential phase of macroevolution is accompanied by the emergence of new evolutionary mechanisms. Certain prerequisites and preadaptations can, therefore, be detected within the previous phase, and the development of new mechanisms does not invalidate the evolutionary mechanisms that were active during earlier phases. As a result, one can observe the emergence of a complex system of interaction composed of the forces and mechanisms that work together to shape the evolution of new forms.

Biological organisms operate in the framework of certain physical, chemical and geological laws. Likewise, the behaviors of social systems and people have certain biological limitations (naturally, in addition to various social-structural, historical, and infrastructural limitations). From the standpoint of Universal Evolution, new forms of evolution that determine phase transitions may result from activities going in different directions. Some forms that are similar in principle may emerge at breakthrough points, but may also result in evolutionary dead-ends. For example, social forms of life emerged among many biological phyla and classes, including bacteria, insects, birds, and mammals. Among insects, in particular, one finds rather highly developed forms of socialization (see, *e.g.*, Robson and Traniello 2002; Ryabko and Reznikova 2009; Reznikova 2011). Yet, despite the seemingly common trajectory and interrelation of social behaviors among these various life forms, the impacts that each have had on the Earth are remarkably different.

Further, regarding information transmission mechanisms, it appears possible to speak about certain ‘evolutionary freaks’. Some of these mechanisms were relatively widespread in the biological evolution of simple organisms, but later became less so. Consider, for example, the horizontal exchange of genetic information (genes) among microorganisms, which makes many useful genetic ‘inventions’ available in a sort of ‘commons’ for microbe communities. Among bacteria, the horizontal transmission of genes contributes to the rapid development of antibiotic resistance (*e.g.*, Markov and Naymark 2009). By contrast, this mechanism of information transmission became obsolete or was transformed into highly specialized mechanisms (*e.g.*, sexual reproduction) in the evolution of more complex organisms. Today, horizontal transmission is mostly confined to the simplest forms of life.

These examples suggest that an analysis of the similarities and differences between the mechanisms of biological and social evolution may help us to understand the general principles of megaevolution[1] in a much fuller way. These similarities and differences may also reveal the driving forces and supra-phase mechanisms (*i.e.*, mechanisms that operate in two or more phases) of megaevolution. One of our previous articles was devoted to the analysis of one such mechanism: *aromorphosis*, the process of widely diffused social innovation that enhances the complexity, adaptability, integrity, and interconnectedness of a society or social system (Grinin, Markov, and Korotayev 2011; see also Grinin and Korotayev 2008, 2009a, 2009b; Grinin, Markov, and Korotayev 2009a, 2009b).

It is important to carefully compare the two types of macroevolution (*i.e.*, biological and social) at various levels and in various aspects. This is necessary because such comparisons often tend to be incomplete and deformed by conceptual extremes. These limitations are evident, for example, in the abovereferenced paper by Mesoudi *et al.* (2006), which attempts to apply a Darwinian method to the study of social evolution. Unfortunately, a failure to recognize or accept important differences between biological and social evolution reduces the overall value of the method that these authors propose. Christopher Hallpike's rather thorough monograph, *Principles of Social Evolution* (1986), provides another illustration of these limitations. Here, Hallpike offers a fairly complete analysis of the similarities and differences between social and biological organisms, but does not provide a clear and systematic comparison between social and biological evolution. In what follows, we hope to avoid similar pitfalls.

### *Biological and Social Evolution: A Comparison at Various Levels*

There are a few important differences between biological and social macroevolution. Nonetheless, it is possible to identify a number of fundamental similarities, including at least three basic sets of shared factors. First, we are discussing very complex, non-equilibrium, but stable systems whose function and evolution can be described by General Systems Theory, as well as by a number of cybernetic principles and laws. Second, we are not dealing with isolated systems, but with the complex interactions between organisms and their external environments. As a result, the reactions of systems to 'external' challenges can be described in terms of general principles that express themselves within a biological reality and a social reality. Third (and finally), a direct 'genetic' link exists between the two types of macroevolution and their mutual influence.

We believe that the laws and forces driving the biological and social phases of Big History can be comprehended more effectively if we apply the concept of biological and social aromorphosis (Grinin, Markov, and Korotayev 2011). There are some important similarities between the evolutionary algorithms of biological and social aromorphoses. Thus, it has been noticed that the basis of biological aromorphosis is usually formed by some partial evolutionary change that… creates significant advantages for an organism, puts it in more favorable conditions for reproduction, multiplies its numbers and its changeability…, thus accelerating the speed of its further evolution. In those favorable conditions, the total restructurization of the whole organization takes place afterwards (Shmal'gauzen 1969: 410; see also Severtsov 1987: 64–76).

During the course of adaptive radiation, such changes in organization diffuse more or less widely (frequently with significant variations).

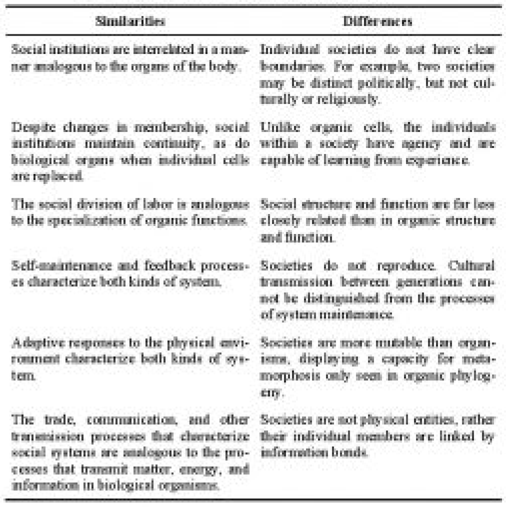
A similar pattern is observed within social macroevolution. An example is the invention and diffusion of iron metallurgy. Iron production was practiced sporadically in the 3rd millennium BCE, but regular production of low-grade steel did not begin until the mid-2nd millennium BCE in Asia Minor (see, *e.g.*, Chubarov 1991: 109). At this point, the Hittite kingdom guarded its monopoly over the new technology. The diffusion of iron technology led to revolutionary changes in different spheres of life, including a significant advancement in plough agriculture and, consequently, in the agrarian system as a whole (Grinin and Korotayev 2006); an intensive development of crafts; an increase in urbanism; the formation of new types of militaries, armed with relatively cheap but effective iron weapons; and the emergence of significantly more developed systems of taxation, as well as information collection and processing systems, that were necessary to support these armies (*e.g.*, Grinin and Korotayev 2007a, 2007b). Ironically, by introducing cheaply made weapons and other tools into the hands of people who might resist the Hittite state, this aromorphosis not only supported the growth of that kingdom, it also laid the groundwork for historical phase shifts.

Considering such cases through the lens of aromorphosis has helped us to detect a number of regularities and rules that appear to be common to biological and social evolution (Grinin, Markov, and Korotayev 2011). Such rules and regularities (*e.g.*, payment for arogenic progress, special conditions for the emergence of aromorphosis, *etc.*) are similar for both biological and social macroevolution. It is important to emphasize, however, that similarity between the two types of macroevolution does not imply commonality. Rather, significant similarities are frequently accompanied by enormous differences. For example, the genomes of chimpanzees and the humans are 98 per cent similar, yet there are enormous intellectual and social differences between chimpanzees and humans that arise from the apparently ‘insignificant’ variations between the two genomes (see Markov and Naymark 2009).

Despite its aforementioned limitations, it appears reasonable to continue the comparison between the two types of macroevolution following the analysis offered by Hallpike (1986). Therefore, it may prove useful to revisit the pertinent observations of this analysis here. Table 1 summarizes the similarities and differences that Hallpike (*Ibid.*: 33–34) finds between social and biological *organisms*.

While we do not entirely agree with all of his observations – for example, the establishment of colonies could be seen as a kind of social reproduction akin to organic reproduction – we do feel that Hallpike comes to a sound conclusion: that similarities between social and biological organisms are, in general, determined by similarities in organization and structure (we would say similarities between different types of systems). As a result, Hallpike believes that one can use certain analogies in which institutions are similar to some organs. In this way, cells may be regarded as similar to individuals, central government similar to the brain, and so on. Examples of this kind of thinking can be found in the classic texts of social theory (see, *e.g.*, Spencer 1898 and Durkheim 1991 [1893]), as well as in more recent work (see, *e.g.*, Heylighen 2011).

**Table 1.** Similarities and differences between social and biological organisms, as described by Hallpike (1986)



| Similarities | Differences |
|---|---|
| Social institutions are interrelated in a manner analogous to the organs of the body. | Individual societies do not have clear boundaries. For example, two societies may be distinct politically, but not culturally or religiously. |
| Despite changes in membership, social institutions maintain continuity, as do biological organs when individual cells are replaced. | Unlike organic cells, the individuals within a society have agency and are capable of learning from experience. |
| The social division of labor is analogous to the specialization of organic functions. | Social structure and function are far less closely related than in organic structure and function. |
| Self-maintenance and feedback processes characterize both kinds of system. | Societies do not reproduce. Cultural transmission between generations cannot be distinguished from the processes of system maintenance. |
| Adaptive responses to the physical environment characterize both kinds of system. | Societies are more mutable than organisms, displaying a capacity for metamorphosis only seen in organic phylogeny. |
| The trade, communication, and other transmission processes that characterize social systems are analogous to the processes that transmit matter, energy, and information in biological organisms. | Societies are not physical entities, rather their individual members are linked by information bonds. |

When comparing biological *species* and societies, Hallpike (1986: 34) singles out the following similarities:
(1) that, like societies, species do not reproduce;
(2) that both have phylogenies reflecting change over time; and
(3) that both are made up of individuals who compete against one another.

Importantly, he also indicates the following *difference*: '[S]ocieties are organized systems, whereas species are simply collections of individual organisms' (Hallpike 1986: 34).

Hallpike tries to demonstrate that, because of the differences between biological and social organisms, the very idea of natural selection does not appear to apply to social evolution. However, we do not find his proofs very convincing on this account, although they do make sense in certain respects. Further, his analysis is confined mainly to the level of the individual organism and the individual society. He rarely considers interactions at the supra-organism level (though he does, of course, discuss the evolution of species). His desire to demonstrate the sterility of Darwinian theory to discussions of social evolution notwithstanding, it seems that Hallpike involuntarily highlights the similarity between biological and social evolution. As he, himself, admits, the analogy between the biological organism and society is quite noteworthy.

Just as he fails to discuss interactions and developments at the level of the supra-organism in great detail, Hallpike does not take into account the point in social evolution where new supra-societal developments emerge (up to the level of the emergence of the World System [*e.g.,* Korotayev 2005, 2007, 2008, 2012; Grinin and Korotayev 2009b]). We contend that it is very important to consider not only evolution at the level of a society but also at the level above individual societies, as well as the point at which both levels are interconnected. The supra-organism level is very important to understanding biological evolution, though the differences between organisms and societies make the importance of this supra-level to understanding social evolution unclear. Thus, it might be more productive to compare societies with ecosystems rather than with organisms or species. However, this would demand the development of special methods, as it would be necessary to consider the society not as a social organism, but as a part of a wider system, which includes the natural and social environment (*cf.,* Lekevičius 2009, 2011).

In our own analysis, we seek to build on the observations of Hallpike while, at the same time, providing a bit more nuance and different scales of analysis. Viewing each as a process involving selection (natural, social, or both), we identify the differences between social and biological evolution at the level of the individual biological organism and individual society, as well as at the supra-organismic and supra-societal level.

### *Natural and Social Selection*

Biological evolution is more additive (cumulative) than substitutive. Put another way: the new is added to the old. By contrast, social evolution (especially over the two recent centuries) is more substitutive than additive: the new replaces the old (Grinin, Markov, and Korotayev 2008, 2011).

Further, the mechanisms that control the emergence, fixation, and diffusion of evolutionary breakthroughs (aromorphoses) differ between biological and social evolution. These differences lead to long-term restructuring in the size and complexity of social organisms. Unlike biological evolution, where some growth of complexity is also observed, social reorganization becomes continuous. In recent decades, societies that do not experience a constant and significant evolution look inadequate and risk extinction.

In addition, the size of societies (and systems of societies) tends to grow constantly through more and more tightly integrative links (this trend has become especially salient in recent millennia), whereas the trend towards increase in the size of biological organisms in nature is rather limited and far from general. At another level of analysis, one can observe the formation of special suprasocietal systems that also tend to grow in size. This is one of the results of social evolution and serves as a method of aromorphosis fixation and diffusion.

### *The Individual Biological Organism and the Individual Society*

It is very important to note that, although biological and social organisms are significantly (actually 'systemically') similar, they are radically different in their capacities to evolve. For example, as indicated by Hallpike (see above), societies are capable of rapid evolutionary metamorphoses that were not observed in the pre-human organic world. In biological evolution, the characteristics acquired by an individual are not inherited by its offspring; thus, they do not influence the very slow process of change.

There are critical differences in how biological and social information are transmitted during the process of evolution. Social systems are not only capable of rapid transformation, they are also able to borrow innovations and new elements from other societies. Social systems may also be transformed consciously and with a certain purpose. Such characteristics are absent in natural biological evolution.

The biological organism does not evolve by itself: evolution may only take place at a higher level (*e.g.*, population, species, *etc.*). By contrast, social evolution can often be traced at the level of the individual social organism (*i.e.*, society). Moreover, it is frequently possible to trace the evolution of particular institutions and subsystems within a social organism. In the process of social evolution the same social organism or institution may experience radical transformation more than once.

### *The Supra-organic and Supra-societal Level*

Given the above-mentioned differences, within the process of social evolution we observe the formation of two types of special supra-societal entity:
(1) amalgamations of societies with varieties of complexity that have analogues in biological evolution, and (2) elements and systems that do not belong to any particular society and lack many analogues in biological evolution.

The first type of amalgamation is rather typical, not only in social but also in biological evolution. There is, however, a major difference between the two kinds of evolution. Any large society usually consists of a whole hierarchy of social systems. For example, a typical agrarian empire might include nuclear families, extended families, clan communities, village communities, primary districts, secondary districts, and provinces, each operating with their own rules of interaction but at the same time interconnected. This kind of supra-societal amalgamation can hardly be compared with a single biological organism (though both systems can still be compared functionally, as is correctly noted by Hallpike [1986]). Within biological evolution, amalgamations of organisms with more than one level of organization (as found in a pack or herd) are usually very unstable and are especially unstable among highly organized animals. Of course, analogues do exist within the communities of some social animals (*e.g.*, social insects, primates). Neither should we forget that scale is important: while we might compare a society with an individual biological organism, we must also consider groups of organisms bound by cooperative relationships (see, *e.g.*, Boyd and Richerson 1996; Reeve and Hölldobler 2007). Such groups are quite common among bacteria and even among viruses. These caveats aside, it remains the case that within social evolution, one observes the emergence of more and more levels: from groups of small sociums to humankind as a whole.

The multiplication of these levels rapidly produces the second kind of amalgamation. It is clear that the level of analysis is very important for comparison of biological and social evolution. Which systems should be compared? Analogues appear to be more frequent when a society (a social organism) is compared to a biological organism or species. However, in many cases, it may turn out to be more productive to compare societies with other levels of the biota’s systemic organization. This might entail comparisons with populations, ecosystems and communities; with particular structural elements or blocks of communities (*e.g.*, with particular fragments of trophic networks or with particular symbiotic complexes); with colonies; or with groups of highly organized animals (*e.g.*, cetaceans, primates, and other social mammals or termites, ants, bees and other social insects).

Thus, here we confront a rather complex and rarely studied methodological problem: which levels of biological and social process are most congruent? What are the levels whose comparison could produce the most interesting results? In general, it seems clear that such an approach should not be a mechanical equation of ‘social organism = biological organism’ at all times and in every situation. The comparisons should be operational and instrumental. This means that we should choose the scale and level of social and biological phenomena, forms, and processes that are adequate for and appropriate to our intended comparisons.

Again, it is sometimes more appropriate to compare a society with an individual biological organism, whereas in other cases it could well be more appropriate to compare the society with a community, a colony, a population, or a species. At yet another scale, as we will see below, in some cases it appears rather fruitful to compare the evolution of the biosphere with the evolution of the anthroposphere.

### *Mathematical Modeling of Biological and Social Macroevolution*

The authors of this article met for the first time in 2005, in the town of Dubna (near Moscow), at what seems to have been the first ever international conference dedicated specifically to Big History studies. Without advance knowledge of one another, we found ourselves in a single session. During the course of the session, we presented two different diagrams. One illustrated population dynamics in China between 700 BCE and 1851 CE, the other illustrated the dynamics of marine Phanerozoic biodiversity over the past 542 million years (Fig. 1).

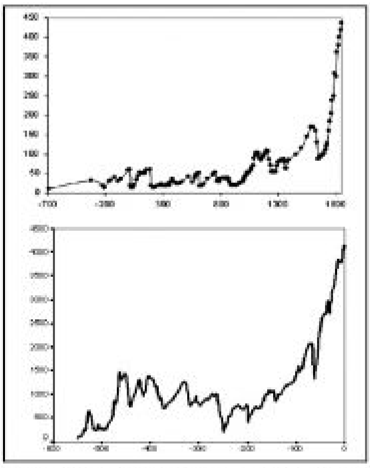


**Fig. 1**. Similarity between the long-term population dynamics of China (top: millions of people, following Korotayev, Malkov, *et al.* 2006b: 47–88) and the dynamics of Phanerozoic marine biodiversity (bottom: number of genera, *N*, following Markov and Korotayev 2007)

The similarity between the two diagrams was striking. This, despite the fact that they depicted the development of very different systems (human population *vs.* biota) at different time scales (hundreds of years *vs.* millions of years), and had been generated using the methods of different sciences (historical demography *vs.* paleontology) with different sources (demographic estimates *vs.* paleontological data). What could have caused similarity of developmental dynamics in very different systems?

* * *

In 1960, von Foerster *et al.* published a striking discovery in the journal *Science*. They showed that between 1 and 1958 CE, the world's population (*N*) dynamics could be described in an extremely accurate way with an astonishingly simple equation:[2]

$$N_t = \frac{C}{(t_0 - t)}, \qquad \text{(Eq 1)}$$

where $N_t$ is the world population at time $t$, and $C$ and $t_0$ are constants, with $t_0$ corresponding to an absolute limit ('singularity' point) at which $N$ would become infinite. Parameter $t_0$ was estimated by von Foerster and his colleagues as 2026.87, which corresponds to November 13, 2026; this made it possible for them to supply their article with a title that was a public-relations masterpiece: 'Doomsday: Friday, 13 November, A.D. 2026'.

Of course, von Foerster and his colleagues did not imply that the world population on that day could actually become infinite. The real implication was that the world population growth pattern that operated for many centuries prior to 1960 was about to end and be transformed into a radically different pattern. This prediction began to be fulfilled only a few years after the 'Doomsday' paper was published as World System growth (and world population growth in particular) began to diverge more and more from the previous blow-up regime. Now no longer hyperbolic, the world population growth pattern is closer to a logistic one (see, *e.g.*, Korotayev, Malkov *et al.* 2006a; Korotayev 2009).

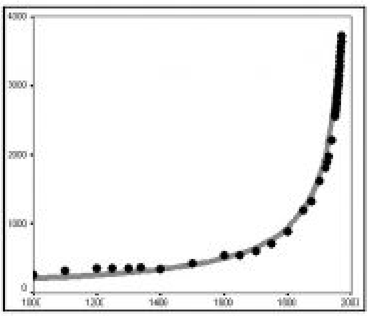
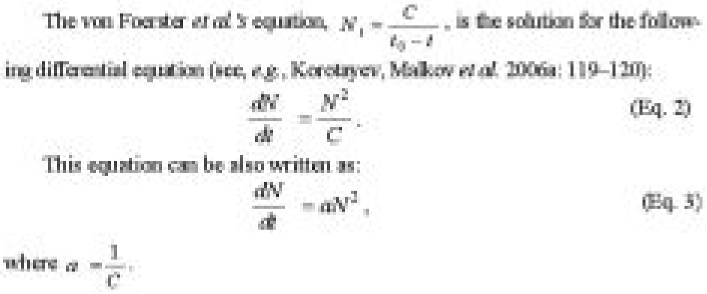


**Fig. 2.** Correlation between empirical estimates of world population (black, in millions of people, 1000–1970) and the curve generated by von Foerster *et al.*'s equation (grey)

Fig. 2 presents the overall correlation between the curve generated by von Foerster *et al.*'s equation and the most detailed series of empirical estimates of world population (McEvedy and Jones 1978, for the period 1000–1950; U.S. Bureau of the Census 2013, for 1950–1970). The formal characteristics are:

$R = 0.998$; $R^2 = 0.996$; $p = 9.4 \times 10^{-17} \approx 1 \times 10^{-16}$. For readers unfamiliar with mathematical statistics: $R^2$ can be regarded as a measure of the fit between the dynamics generated by a mathematical model and the empirically observed situation, and can be interpreted as the proportion of the variation accounted for by the respective equation. Note that 0.996 also can be expressed as 99.6 per cent.[3] Thus, von Foerster *et al.*'s equation accounts for an astonishing 99.6 per cent of all the macrovariation in world population, from 1000 CE through 1970, as estimated by McEvedy and Jones (1978) and the U.S. Bureau of the Census (2013).[4] Note also that the empirical estimates of world population find themselves aligned in an extremely neat way along the hyperbolic curve, which convincingly justifies the designation of the pre-1970s world population growth pattern as 'hyperbolic'.

The von Foerster *et al.'s* equation, , is the solution for the following differential equation (see, *e.g.*, Korotayev, Malkov *et al.* 2006a: 119–120):



The von Foerster *et al.'s* equation, $N_t = \frac{C}{t_0 - t}$, is the solution for the following differential equation (see, *e.g.*, Korotayev, Malkov *et al.* 2006a: 119–120):

$$\frac{dN}{dt} = \frac{N^2}{C}. \qquad \text{(Eq. 2)}$$

This equation can be also written as:

$$\frac{dN}{dt} = aN^2, \qquad \text{(Eq. 3)}$$

where $a = \frac{1}{C}$.

What is the meaning of this mathematical expression? In our context, *dN/dt* denotes the absolute population growth rate at a certain moment in time. Hence, this equation states that the absolute population growth rate at any moment in time should be proportional to the square of world population at this moment. This significantly demystifies the problem of hyperbolic growth. To explain this hyperbolic growth, one need only explain why for many millennia the world population's absolute growth rate tended to be proportional to the square of the population.

The main mathematical models of hyperbolic growth in the world population (Taagapera 1976, 1979; Kremer 1993; Cohen 1995; Podlazov 2004; Tsirel 2004; Korotayev 2005, 2007, 2008, 2009, 2012; Korotayev, Malkov *et al.* 2006a: 21–36; Golosovsky 2010; Korotayev and Malkov 2012) are based on the following two assumptions:
*'the Malthusian (Malthus 1978 [1798]) assumption that population is limited by the available technology, so that the growth rate of population is proportional to the growth rate of technology' (Kremer 1993: 681–682),*[5] *and*
*the idea that '[h]igh population spurs technological change because it increases the number of potential inventors… In a larger population there will be proportionally more people lucky or smart enough to come up with new ideas', thus, 'the growth rate of technology is proportional to total population'(Kremer 1993: 685).*[6]

Here Kremer uses the main assumption of Endogenous Technological Growth theory (see, *e.g.*, Kuznets 1960; Grossman and Helpman 1991; Aghion and Howitt 1998; Simon 1977, 2000; Komlos and Nefedov 2002; Jones 1995, 2005).

The first assumption looks quite convincing. Indeed, throughout most of human history the world population was limited by the technologically determined ceiling of the carrying capacity of land. For example, with foraging subsistence technologies the Earth could not support more than 8 million people because the amount of naturally available useful biomass on this planet is limited. The world population could only grow over this limit when people started to apply various means to artificially increase the amount of available biomass that is with the transition from foraging to food production. Extensive agriculture is also limited in terms of the number of people that it can support. Thus, further growth of the world population only became possible with the intensification of agriculture and other technological improvements (see, *e.g.*, Turchin 2003; Korotayev, Malkov *et* *al.* 2006a, 2006b; Korotayev and Khaltourina 2006). However, as is well known, the technological level is not constant, but variable (see, *e.g.*, Grinin 2007a, 2007b, 2012), and in order to describe its dynamics the second basic assumption is employed.

As this second supposition was, to our knowledge, first proposed by Simon Kuznets (1960), we shall denote the corresponding type of dynamics as ‘Kuznetsian’. (The systems in which the Kuznetsian population-technological dynamics are combined with Malthusian demographic dynamics will be denoted as ‘Malthusian-Kuznetsian’.) In general, we find this assumption rather plausible – in fact, it is quite probable that, other things being equal, within a given period of time, five million people will make approximately five times more inventions than one million people.

This assumption was expressed mathematically by Kremer in the following way:

$$\frac{dT}{dt} = kNT \, . \qquad \text{(Eq. 4)}$$

This equation simply says that the absolute technological growth rate at a given moment in time ($dT/dt$) is proportional to the technological level ($T$) observed at this moment (the wider the technological base, the higher the number of inventions that can be made on its basis). On the other hand, this growth rate is also proportional to the population ($N$): the larger the population, the larger the number of potential inventors.[7]

When united in one system, Malthusian and Kuznetsian equations account quite well for the hyperbolic growth of the world population observed before the early 1990s (see, *e.g.*, Korotayev 2005, 2007, 2008, 2012; Korotayev, Malkov *et al.* 2006a). The resultant models provide a rather convincing explanation of *why,* throughout most of human history, the world population followed the hyperbolic pattern with the absolute population growth rate tending to be proportional to $N^2$. For example, why would the growth of population from, say, 10 million to 100 million, result in the growth of $dN/dt$ 100 times? The above mentioned models explain this rather convincingly. The point is that the growth of world population from 10 to 100 million implies that human subsistence technologies also grew approximately 10 times (given that it will have proven, after all, to be able to support a population ten times larger). On the other hand, the tenfold population growth also implies a tenfold growth in the number of potential inventors, and, hence, a tenfold increase in the relative technological growth rate. Thus, the absolute technological growth rate would expand 10 × 10 = 100 times as, in accordance with Eq. 4, an order of magnitude higher number of people having at their disposal an order of magnitude wider technological base would tend to make two orders of magnitude more inventions. If, as throughout the Malthusian epoch, the world population ($N$) tended toward the technologically determined carrying capacity of the Earth, we have good reason to expect that $dN/dt$ should also grow just by about 100 times.

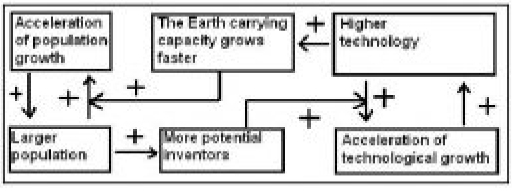


**Fig. 3.** Cognitive scheme of the nonlinear second order positive feedback between technological development and demographic growth

In fact, it can be shown (see, *e.g.*, Korotayev, Malkov *et al.* 2006a, 2006b; Korotayev and Khaltourina 2006) that the hyperbolic pattern of the world's population growth could be accounted for by a nonlinear second-order positive feedback mechanism that was long ago shown to generate just the hyperbolic growth, also known as the 'blow-up regime' (see, *e.g.*, Kurdyumov 1999). In our case, this nonlinear second-order positive feedback looks as follows: more people – more potential inventors – faster technological growth – faster growth of the Earth's carrying capacity – faster population growth – more people allow for more potential inventors – faster technological growth, and so on (see Fig. 3).

Note that the relationship between technological development and demographic growth cannot be analyzed through any simple cause-and-effect model, as we observe a true dynamic relationship between these two processes – each of them is both the cause and the effect of the other.

The feedback system described here should be identified with the process of 'collective learning' described, principally, by Christian (2005: 146–148). The mathematical models of World System development discussed in this article can be interpreted as models of the influence that collective learning has on global social evolution (*i.e.*, the evolution of the World System). Thus, the rather peculiar hyperbolic shape of accelerated global development prior to the early 1970s may be regarded as a product of global collective learning. We have also shown (Korotayev, Malkov *et al.* 2006a: 34–66) that, for the period prior to the 1970s, World System economic and demographic macrodynamics, driven by the above-mentioned positive feedback loops, can simply and accurately be described with the following model:

$$\frac{dN}{dt} = aSN, \qquad \text{(Eq. 5)}$$

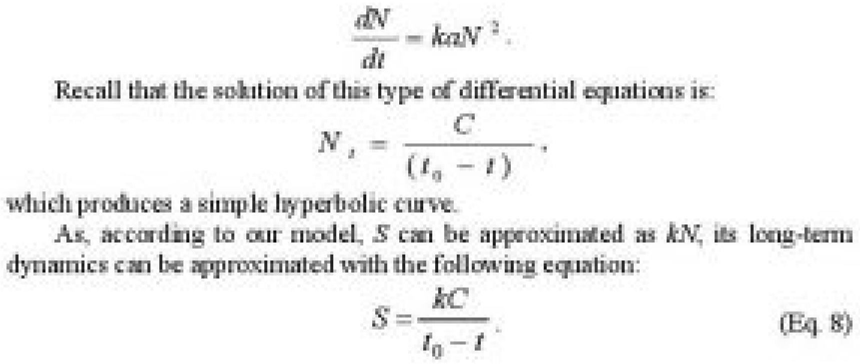
$$\frac{dS}{dt} = bNS. \qquad \text{(Eq. 6)}$$

The world GDP (*G*) can be calculated using the following equation:

$$G = mN + SN, \qquad \text{(Eq. 7)}$$

where *G* is the world GDP, *N* is population, and *S* is the produced surplus per capita, over the subsistence amount (*m*) that is minimally necessary to reproduce the population with a zero growth rate in a Malthusian system (thus, $S = g - m$, where *g* denotes per capita GDP); *a* and *b* are parameters.

The mathematical analysis of the basic model (not described here) suggests that up to the 1970s, the amount of *S* should be proportional, in the long run, to the World System's population: $S = kN$. Our statistical analysis of available empirical data has confirmed this theoretical proportionality (Korotayev, Malkov *et al.* 2006a: 49–50). Thus, in the right-hand side of Eq. 6, *S* can be replaced with *kN*, resulting in the following equation:



$$\frac{dN}{dt} = kaN^2 .$$

Recall that the solution of this type of differential equations is:

$$N_t = \frac{C}{(t_0 - t)} ,$$

which produces a simple hyperbolic curve.

As, according to our model, $S$ can be approximated as $kN$, its long-term dynamics can be approximated with the following equation:

$$S = \frac{kC}{t_0 - t} . \qquad \text{(Eq. 8)}$$

Thus, the long-term dynamics of the most dynamic component of the world GDP, *SN*, the 'world surplus product', can be approximated as follows:

$$SN = \frac{kC^2}{(t_0 - t)^2} . \qquad \text{(Eq. 9)}$$

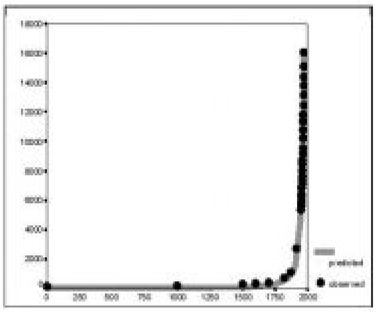


**Fig. 4.** The fit between predictions of a quadratic-hyperbolic model and observed world GDP dynamics, 1–1973 CE (in billions of 1990 international dollars, PPP)

*Note:* $R = .9993$, $R^2 = .9986$, $p << .0001$. The black markers correspond to Maddison's (2001) estimates (Maddison's estimates of the world per capita GDP for 1000 CE has been corrected on the basis of [Meliantsev 2004]). The grey solid line has been generated by the following equation:

$$G = \frac{17749573.1}{(2006 - t)^2}.$$

Thus, up to the 1970s the hyperbolic growth of the world population was accompanied by the quadratic-hyperbolic growth of the world GDP, as suggested by our model. Note that the hyperbolic growth of the world population and the quadratic-hyperbolic growth of the world GDP are very tightly connected processes, actually two sides of the same coin, two dimensions of one process propelled by nonlinear second-order positive feedback loops between the technological development and demographic growth (see Fig. 5).

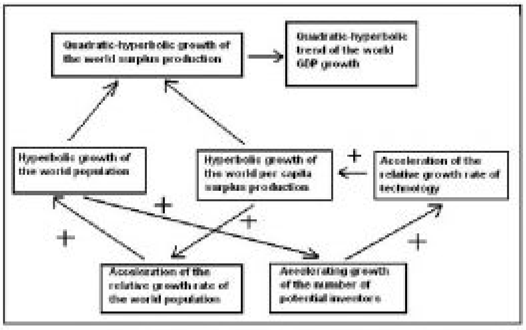


**Fig. 5.** Cognitive scheme of the world economic growth generated by nonlinear second-order positive feedback between technological development and demographic growth

We have also demonstrated (Korotayev, Malkov *et al.* 2006a: 67–80) that the World System population's literacy ($l$) dynamics are rather accurately described by the following differential equation:

$$\frac{dl}{dt} = aSl\,(1-l), \qquad \text{(Eq. 10)}$$

where $l$ is the proportion of the population that is literate, $S$ is per capita surplus, and $a$ is a constant. In fact, this is a version of the autocatalytic model. Literacy growth is proportional to the fraction of the population that is literate, $l$ (potential teachers), to the fraction of the population that is illiterate, $(1 – l)$ (potential pupils), and to the amount of per capita surplus $S$, since it can be used to support educational programs. (Additionally, $S$ reflects the technological level $T$ that implies, among other things, the level of development of educational technologies.) From a mathematical point of view, Eq. 9 can be regarded as logistic where saturation is reached at literacy level $l = 1$. $S$ is responsible for the speed with which this level is being approached.

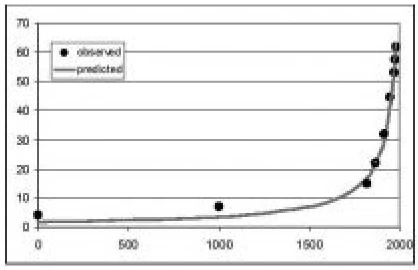


**Fig. 6.** The fit between predictions of the hyperbolic model and observed world literacy dynamics, 1–1980 CE (%%)

*Note:* $R = 0.997$, $R^2 = 0.994$, $p << 0.0001$. Black dots correspond to World Bank (2013) estimates for the period since 1970, and to Meliantsev's (2004) estimates for the earlier period. The grey solid line has been generated by the following equation:

$$l_t = \frac{3769.264}{(2040 - t)^2}.$$

The best-fit values of parameters $C$ (3769.264) and $t_0$ (2040) have been calculated with the least squares method.

It is important to stress that with low values of $l$ (which correspond to most of human history, with recent decades being the exception), the rate of increase in world literacy generated by this model (against the background of hyperbolic growth of $S$) can be approximated rather accurately as hyperbolic (see Fig. 6).

The overall number of literate people is proportional both to the literacy level and to the overall population. As both of these variables experienced hyperbolic growth until the 1960s/1970s, one has sufficient grounds to expect that until recently the overall number of literate people in the world ($L$)[8] was growing not just hyperbolically, but rather in a quadratic-hyperbolic way (as was world GDP). Our empirical test has confirmed this – the quadratic-hyperbolic model describes the growth of the literate population of this planet with an extremely good fit indeed (see Fig. 7).

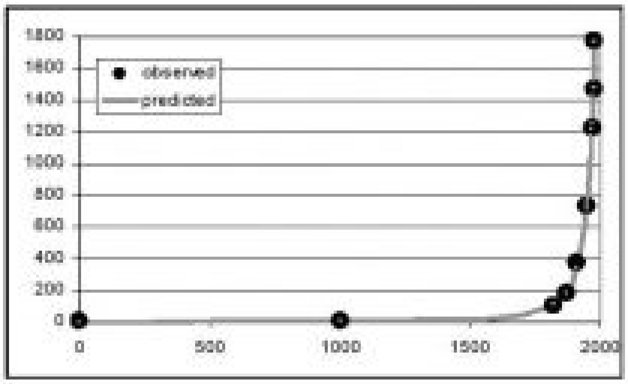


**Fig. 7.** The fit between predictions of the quadratic-hyperbolic model and observed world literate population dynamics, 1–1980 CE ($L$, millions)

*Note:* $R = 0.9997$, $R^2 = 0.9994$, $p << 0.0001$. The black dots correspond to UNESCO/World Bank (2014) estimates for the period since 1970, and to Melyantsev's (2004) estimates for the earlier period; we have also taken into account the changes of age structure on the basis of UN Population Division (2014) data. The grey solid line has been generated by the following equation:

$$L_t = \frac{4958551}{(2033-t)^2},$$

The best-fit values of parameters $C$ (4958551) and $t_0$ (2035) have been calculated with the least squares method.

Similar processes are observed with respect to world urbanization, the macrodynamics of which appear to be described by the differential equation:

$$\frac{du}{dt} = bSu\,(u_{\lim} - u)\,, \qquad \text{(Eq. 11)}$$

where $u$ is the proportion of the population that is urban, $S$ is per capita surplus produced with the given level of the World System's technological development, $b$ is a constant, and $u_{\lim}$ is the maximum possible proportion of the population that can be urban. Note that this model implies that during the Malthusian-Kuznetsian era of the blow-up regime, the hyperbolic growth of world urbanization must have been accompanied by a quadratic-hyperbolic growth of the urban population of the world, as supported by our empirical tests (see Figs 8–9).

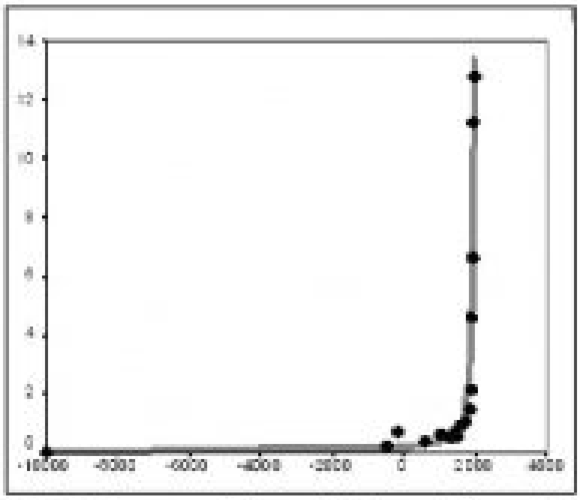


**Fig. 8.** The fit between predictions of the hyperbolic model and empirical estimates of world megaurbanization dynamics (% of the world population living in cities with > 250,000 inhabitants), 10,000 BCE – 1960 CE

*Note:* $R = 0.987$, $R^2 = 0.974$, $p \ll 0.0001$. The black dots correspond to Chandler's (1987) estimates, UN Population Division (2014), Modelski (2003), and Gruebler (2006). The grey solid line has been generated by the following equation:

$$u_t = \frac{403.012}{(1990 - t)}.$$

The best-fit values of parameters $C$ (403.012) and $t_0$ (1990) have been calculated with the least squares method. For comparison, the best fit ($R^2$) obtained here for the exponential model is 0.492.

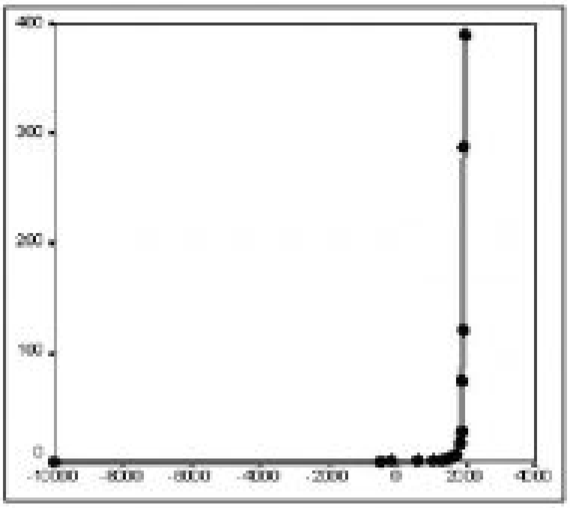


**Fig. 9.** The fit between predictions of the quadratic-hyperbolic model and the observed dynamics of world urban population living in cities with > 250,000 inhabitants (millions), 10,000 BCE – 1960 CE

*Note:* $R = 0.998$, $R^2 = 0.996$, $p << 0.0001$. The black markers correspond to estimates of Chandler (1987) and UN Population Division (2014). The grey solid line has been generated by the following equation:

$$U_t = \frac{912057.9}{(2008 - t)^2},$$

The best-fit values of parameters $C$ (912057.9) and $t_0$ (2008) have been calculated with the least squares method. For comparison, the best fit ($R^2$) obtained here for the exponential model is 0.637.

Within this context it is hardly surprising to find that the general macrodynamics of largest settlements within the World System are also quadratic-hyperbolic (see Fig. 10).

As has been demonstrated by socio-cultural anthropologists working across cultures (see, *e.g.*, Naroll and Divale 1976; Levinson and Malone 1980: 34), for pre-agrarian, agrarian, and early industrial cultures the size of the largest settlement is a rather effective indicator of the general sociocultural complexity of a social system. This, of course, suggests that the World System’s general sociocultural complexity also grew, in the Malthusian-Kuznetsian era, in a generally quadratic-hyperbolic way.

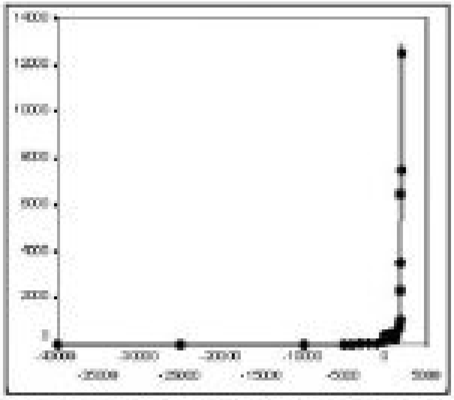


**Fig. 10.** The fit between predictions of the quadratic-hyperbolic model and the observed dynamics of size of the largest settlement of the world (thousands of inhabitants), 10,000 BCE – 1950 CE

*Note:* $R = 0.992$, $R^2 = 0.984$, $p << 0.0001$. The black markers correspond to estimates of Modelski (2003) and Chandler (1987). The grey solid line has been generated by the following equation:

$$U_{max\,t} = \frac{104020618.573}{(2040 - t)^2}.$$

The best-fit values of parameters $C$ (104020618.5) and $t_0$ (2040) have been calculated with the least squares method. For comparison, the best fit ($R^2$) obtained here for the exponential model is 0.747.

Turning to a more concrete case study, as suggested at the beginning of this section, the hyperbolic model is particularly effective for describing the long-term population dynamics of China, the country with the best-known demographic history. The Chinese population curve reflects not only a hyperbolic trend, but also cyclical and stochastic dynamics. These components of long-term population dynamics in China, as well as in other complex agrarian societies, have been discussed extensively (see, *e.g.*, Braudel 1973; Abel 1980; Usher 1989; Goldstone 1991; Chu and Lee 1994; Komlos and Nefedov 2002; Turchin 2003, 2005a, 2005b; Nefedov 2004; Korotayev 2006; Korotayev and Khaltourina 2006; Korotayev, Malkov *et al.* 2006b; Turchin and Korotayev 2006; Korotayev, Komarova *et al.* 2007; Grinin, Korotayev *et al.* 2008; Grinin, Malkov *et al.* 2009; Turchin and Nefedov 2009; van Kessel-Hagesteijn 2009; Korotayev, Khaltourina, Malkov *et al.* 2010; Korotayev, Khaltourina *et al.* 2010; Grinin and Korotayev 2012).

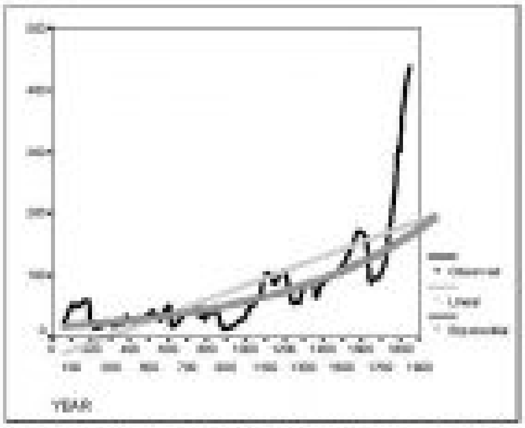


**Fig. 11.** Population dynamics of China (million people, following Korotayev, Malkov, *et al.* 2006b: 47–88), 57–1851 CE. Fit with Linear and Exponential Models

*Note:* Linear model: $R^2 = 0.469$. Exponential model: $R^2 = 0.600$.

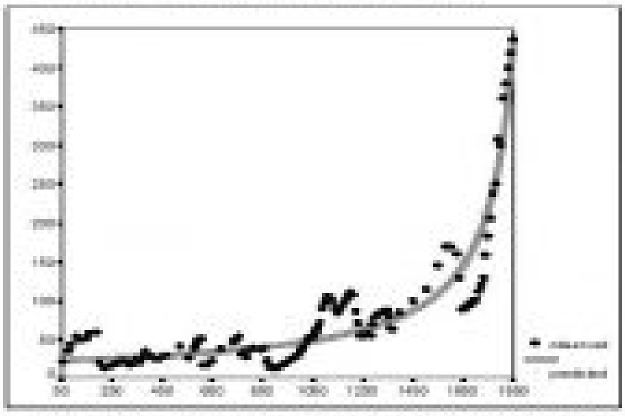


**Fig. 12.** Fit between a hyperbolic model and observed population dynamics of China (million people), 57–1851 CE

*Note:* $R^2 = 0.884$. The grey solid line has been generated by the following equation:

$$N_t = \frac{33431}{1915 - t}.$$

As we have observed with respect to world population dynamics, even before the start of its intensive modernization, the population dynamics of China were characterized by a pronounced hyperbolic trend (Figs 11 and 12).

The hyperbolic model describes traditional Chinese population dynamics *much* more accurately than either linear or exponential models.

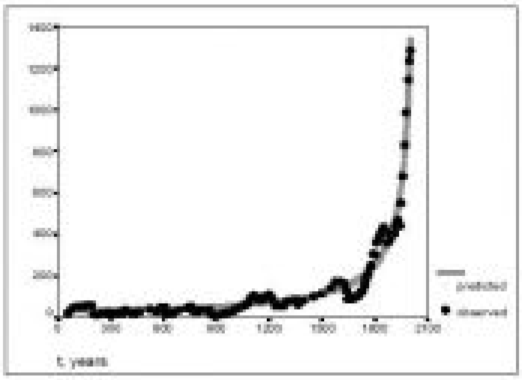


**Fig. 13.** Fit between a hyperbolic model and observed population dynamics of China (million people, following Korotayev, Malkov, *et al.* 2006b: 47–88), 57–2003 CE

*Note:* $R^2 = 0.968$. The grey solid line has been generated by the following equation:

$$N_t = \frac{63150}{2050 - t}.$$

The hyperbolic model describes the population dynamics of China in an especially accurate way if we take the modern period into account (Fig. 13).

It is curious that, as we noted above, the dynamics of marine biodiversity are strikingly similar to the population dynamics of China. The similarity probably derives from the fact that both curves are produced by the interference of the same three components (the general hyperbolic trend, as well as cyclical and stochastic dynamics). In fact, there is a lot of evidence that some aspects of biodiversity dynamics are stochastic (Raup *et al.* 1973; Sepkoski 1994; Markov 2001; Cornette and Lieberman 2004), while others are periodic (Raup and Sepkoski 1984; Rohde and Muller 2005). In any event, the hyperbolic model describes marine biodiversity (measured by number of genera) through the Phanerozoic much more accurately than an exponential model (Fig. 14).

When measured by number of species, the fit between the empirically observed marine biodiversity dynamics and the hyperbolic model becomes even better (Fig. 15).

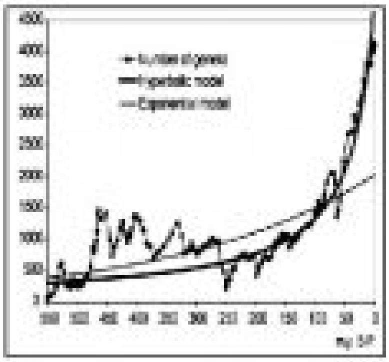


**Fig. 14.** Global change in marine biodiversity (number of genera, *N*) through the Phanerozoic (following Markov and Korotayev 2007)

*Note:* Exponential model: $R^2 = 0.463$. Hyperbolic model: $R^2 = 0.854$. The hyperbolic line has been generated by the following equation:

$$N_t = \frac{183320}{57-t}.$$

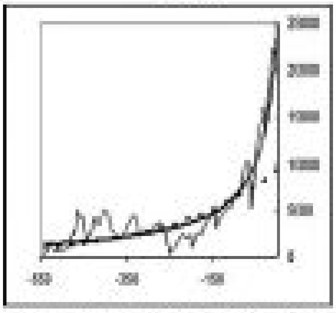


**Fig. 15.** Global change in marine biodiversity (number of species, *N*) through the Phanerozoic (following Markov and Korotayev 2008)

*Note:* Exponential model: $R^2 = 0.51$. Hyperbolic model: $R^2 = 0.91$. The hyperbolic line has been generated by the following equation:

$$N_t = \frac{892874}{35-t}.$$

Likewise, the hyperbolic model describes continental biodiversity in an especially accurate way (Fig. 16).

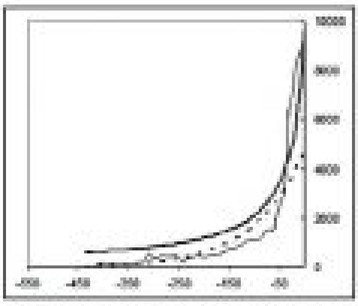


**Fig. 16.** Global change in continental biodiversity (number of genera, *N*) through the Phanerozoic (following Markov and Korotayev 2008)

*Note:* Exponential model: $R^2 = 0.86$. Hyperbolic model: $R^2 = 0.94$. The hyperbolic line has been generated by the following equation:

$$N_t = \frac{272095}{29-t}.$$

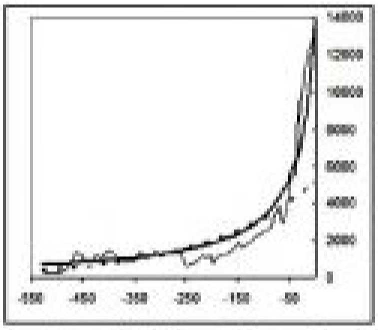


**Fig. 17.** Global change in total biodiversity (number of genera, *N*) through the Phanerozoic (following Markov and Korotayev 2008)

*Note:* Exponential model: $R^2 = 0.67$. Hyperbolic model: $R^2 = 0.95$. The hyperbolic line has been generated by the following equation:

$$N_t = \frac{434635}{30-t}.$$

The hyperbolic dynamics are most prominent when both marine and continental biotas are considered together. This fact can be interpreted as a proof of the integrated nature of the biosphere. But why, throughout the Phanerozoic, did global biodiversity tend to follow a hyperbolic trend similar to that which we observed for the World System in general and China in particular?

As we have noted above, in sociological models of macrohistorical dynamics, the hyperbolic pattern of world population growth arises from non-linear second-order positive feedback (more or less identical with the mechanism of collective learning) between demographic growth and technological development. Based on analogy with these sociological models and diverse paleontological data, we suggest that the hyperbolic character of biodiversity growth can be similarly accounted for by non-linear second-order positive feedback between diversity growth and the complexity of community structure: more genera – higher alpha diversity – enhanced stability and 'buffering' of communities – lengthening of average life span of genera, accompanied by a decrease in the extinction rate – faster diversity growth – more genera – higher alpha diversity, and so on. Indeed, this begins to appear as a (rather imperfect) analogue of the collective learning mechanism active in social macroevolution.

The growth of genus richness throughout the Phanerozoic was mainly due to an increase in the average longevity of genera and a gradual accumulation of long-lived (stable) genera in the biota. This pattern reveals itself in a decrease in the extinction rate. Interestingly, in both biota and humanity, growth was facilitated by a decrease in mortality rather than by an increase in the birth rate. The longevity of newly arising genera was growing in a stepwise manner. The most short-lived genera appeared during the Cambrian; more long-lived genera appeared in Ordovician to Permian; the next two stages correspond to the Mesozoic and Cenozoic (Markov 2001, 2002). We suggest that diversity growth can facilitate the increase in genus longevity via progressive stepwise changes in the structure of communities.

Most authors agree that three major biotic changes resulted in the fundamental reorganization of community structure during the Phanerozoic: Ordovician radiation, end-Permian extinction, and end-Cretaceous extinction (Bambach 1977; Sepkoski *et al.* 1981; Sepkoski 1988, 1992; Markov 2001; Bambach *et al.* 2002). Generally, after each major crisis, the communities became more complex, diverse, and stable. The stepwise increase of alpha diversity (*i.e.,* the average number of species or genera in a community) through the Phanerozoic was demonstrated by Bambach (1977) and Sepkoski (1988). Although Powell and Kowalewski (2002) have argued that the observed increase in alpha diversity might be an artifact caused by several specific biases that influenced the taxonomic richness of different parts of the fossil record, there is evidence that these biases largely compensated for one another so that the observed increase in alpha diversity was probably underestimated rather than overestimated (Bush and Bambach 2004).

Another important symptom of progressive development of communities is an increase in the evenness of species (or genus) abundance distribution. In primitive, pioneer, or suppressed communities, this distribution is strongly uneven: the community is overwhelmingly dominated by a few very abundant species. In more advanced, climax, or flourishing communities, this distribution is more even (Magurran 1988). The former type of community is generally more vulnerable. The evenness of species richness distribution in communities increased substantially during the Phanerozoic (Powell and Kowalewski 2002; Bush and Bambach 2004). It is most likely there was also an increase in habitat utilization, total biomass, and the rate of trophic flow in biota through the Phanerozoic (Powell and Kowalewski 2002).

The more complex the community, the more stable it is due to the development of effective interspecies interactions and homeostatic mechanisms based on the negative feedback principle. In a complex community, when the abundance of a species decreases, many factors arise that facilitate its recovery (*e.g.,* food resources rebound while predator populations decline). Even if the species becomes extinct, its vacant niche may ‘recruit’ another species, most probably a related one that may acquire morphological similarity with its predecessor and thus will be assigned to the same genus by taxonomists. So a complex community can facilitate the stability (and longevity) of its components, such as niches, taxa and morphotypes. This effect reveals itself in the phenomenon of 'coordinated stasis'. The fossil record contains many examples in which particular communities persist for million years while the rates of extinction and taxonomic turnover are minimized (Brett *et al.* 1996, 2007).

Selective extinction leads to the accumulation of 'extinction-tolerant' taxa in the biota (Sepkoski 1991b). Although there is evidence that mass extinctions can be nonselective in some aspects (Jablonski 2005), they are obviously highly selective with respect to the ability of taxa to endure unpredictable environmental changes. This can be seen, for instance, in the selectivity of the end-Cretaceous mass extinction with respect to the time of the first occurrence of genera. In younger cohorts, the extinction level was higher than that of the older cohorts (see Markov and Korotayev 2007: fig. 2). The same pattern can be observed during the periods of 'background' extinction as well. This means that genera differ in their ability to survive extinction events, and that extinction-tolerant genera accumulate in each cohort over the course of time. Thus, taxa generally become more stable and long-lived through the course of evolution, apart from the effects of communities. The communities composed of more stable taxa would be, in turn, more stable themselves, thus creating positive feedback.

The stepwise change of dominant taxa plays a major role in biotic evolution. This pattern is maintained not only by the selectivity of extinction (discussed above), but also by the selectivity of the recovery after crises (Bambach *et al.* 2002). The taxonomic structure of the Phanerozoic biota was changing in a stepwise way, as demonstrated by the concept of three sequential 'evolutionary faunas' (Sepkoski 1992). There were also stepwise changes in the proportion of major groups of animals with different ecological and physiological parameters. There was stepwise growth in the proportion of motile genera to non-motile, 'physiologically buffered' genera to 'unbuffered', and predators to prey (Bambach *et al.* 2002). All these trends should have facilitated the stability of communities. For example, the diversification of predators implies that they became more specialized. A specialized predator regulates its prey's abundance more effectively than a non-specialized predator.

There is also another possible mechanism of second-order positive feedback between diversity and its growth rate. Recent research has demonstrated a shift in typical relative-abundance distributions in paleocommunities after the Paleozoic (Wagner *et al.* 2006). One possible interpretation of this shift is that community structure and the interactions between species in the communities became more complex. In post-Paleozoic communities, new species probably increased ecospace more efficiently, either by facilitating opportunities for additional species or by niche construction (Wagner *et al.* 2006; Solé *et al.* 2002; Laland *et al.* 1999). This possibility makes the mechanisms underlying the hyperbolic growth of biodiversity and human population even more similar, because the total ecospace of the biota is analogous to the 'carrying capacity of the Earth' in demography. As far as new species can increase ecospace and facilitate opportunities for additional species entering the community, they are analogous to the 'inventors' of the demographic models whose inventions increase the carrying capacity of the Earth.

Exponential and logistic models of biodiversity imply several possible ways in which the rates of origination and extinction may change through time (Sepkoski 1991a). For instance, exponential growth can be derived from constant per-taxon extinction and origination rates, the latter being higher than the former. However, actual paleontological data suggest that origination and extinction rates did not follow any distinct trend through the Phanerozoic, and their changes through time look very much like chaotic fluctuations (Cornette and Lieberman 2004). Therefore, it is more difficult to find a simple mathematical approximation for the origination and extinction rates than for the total diversity. In fact, the only critical requirement of the exponential model is that the difference between the origination and extinction through time should be proportional to the current diversity level:

$$(N_o - N_e)/\Delta t \approx kN, \qquad \text{(Eq. 12)}$$

where $N_o$ and $N_e$ are the numbers of genera with, respectively, first and last occurrences within the time interval $\Delta t$, and $N$ is the mean diversity level during the interval. The same is true for the hyperbolic model. It does not predict the exact way in which origination and extinction should change, but it does predict that their difference should be roughly proportional to the square of the current diversity level:

$$(N_o - N_e)/\Delta t \approx kN^2. \qquad \text{(Eq. 13)}$$

In the demographic models discussed above, the hyperbolic growth of the world population was not decomposed into separate trends of birth and death rates. The main driving force of this growth was presumably an increase in the carrying capacity of the Earth. The way in which this capacity was realized – either by decreasing death rate or by increasing birth rate, or both – depended upon many factors and may varied from time to time.

The same is probably true for biodiversity. The overall shape of the diversity curve depends mostly on the differences in the mean rates of diversity growth in the Paleozoic (low), Mesozoic (moderate), and Cenozoic (high). The Mesozoic increase was mainly due to a lower extinction rate (compared to the Paleozoic), while the Cenozoic increase was largely due to a higher origination rate (compared to the Mesozoic) (see Markov and Korotayev 2007: 316, figs. 3a and b). This probably means that the acceleration of diversity growth during the last two eras was driven by different mechanisms of positive feedback between diversity and its growth rate. Generally, the increment rate ($(N_o - N_e)/\Delta t$) was changing in a more regular way than the origination rate $N_o/\Delta t$ and extinction rate $N_e/\Delta t$. The large-scale changes in the increment rate correlate better with $N^2$ than with $N$ (see Markov and Korotayev 2007: 316, Figs 3c and d), thus supporting the hyperbolic rather than the exponential model.

### *Conclusion*

In mathematical models of historical macrodynamics, a hyperbolic pattern of world population growth arises from non-linear second-order positive feedback between the demographic growth and technological development. Based on the analogy with macrosociological models and diverse paleontological data, we suggest that the hyperbolic character of biodiversity growth can be similarly accounted for by non-linear second-order positive feedback between the diversity growth and the complexity of community structure. This hints at the presence, within the biosphere, of a certain analogue to the collective learning mechanism. The feedback can work via two parallel mechanisms: (1) a decreasing extinction rate (more surviving taxa – higher alpha diversity – communities become more complex and stable – extinction rate decreases – more taxa, and so on), and (2) an increasing origination rate (new taxa – niche construction – newly formed niches occupied by the next ‘generation’ of taxa – new taxa, and so on). The latter possibility makes the mechanisms underlying the hyperbolic growth of biodiversity and human population even more similar, because the total ecospace of the biota is analogous to the 'carrying capacity of the Earth' in demography. As far as new species can increase ecospace and facilitate opportunities for additional species entering the community, they are analogous to the 'inventors' of the demographic models whose inventions increase the carrying capacity of the Earth.

The hyperbolic growth of Phanerozoic biodiversity suggests that 'cooperative' interactions between taxa can play an important role in evolution, along with generally accepted competitive interactions. Due to this 'cooperation' (which may be roughly analogous to 'collective learning'), the evolution of biodiversity acquires some features of a self-accelerating process. The same is naturally true of cooperation/collective learning in global social evolution. This analysis suggests that we can trace rather similar macropatterns within both the biological and social phases of Big History. These macropatterns can be represented by relatively similar curves and described accurately with very simple mathematical models.

NOTES

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[1] We denote as *mega*evolution all the process of evolution throughout the whole of Big History, whereas we denote as *macro*evolution the process of evolution during one of its particular phases.

[2] To be exact, the equation proposed by von Foerster and his colleagues looked as follows: . However, as von Hoerner (1975) and Kapitza (1999) showed, it can be simplified as .

[3] The second characteristic ($p$, standing for 'probability') is a measure of the correlation's statistical significance. A bit counter-intuitively, the lower the value of $p$, the higher the statistical significance of the respective correlation. This is because $p$ indicates the probability that the observed correlation could be accounted solely by chance. Thus, $p = 0.99$ indicates an extremely low statistical significance, as it means that there are 99 chances out of 100 that the observed correlation is the result of a coincidence, and, thus, we can be quite confident that

there is no systematic relationship (at least, of the kind that we study) between the two respective variables. On the other hand, $p = 1 \times 10^{-16}$ indicates an extremely high statistical significance for the correlation, as it means that there is only one chance out of 10,000,000,000,000,000 that the observed correlation is the result of pure coincidence (a correlation is usually considered statistically significant once $p < 0.05$).

[4] In fact, with slightly different parameters ($C = 164890.45$; $t_0 = 2014$) the fit ($R^2$) between the dynamics generated by von Foerster's equation and the macrovariation of world population for 1000–1970 CE as estimated by McEvedy and Jones (1978) and the U.S. Bureau of the Census (2013) reaches 0.9992 (99.92 per cent); for 500 BCE – 1970 CE this fit increases to 0.9993 (99.93 per cent) with the following parameters: $C = 171042.78$; $t_0 = 2016$.

[5] In addition to this, the absolute growth rate is proportional to the population itself. With a given relative growth rate, a larger population will increase more in absolute number than a smaller one.

[6] Note that 'the growth rate of technology' here means the relative growth rate (*i.e.*, the level to which technology will grow in a given unit of time in proportion to the level observed at the beginning of this period).

[7] Kremer did not test this hypothesis empirically in a direct way. Note, however, that our own empirical test of this hypothesis has supported it (see Korotayev, Malkov *et al.* 2006b: 141–146).

[8] Since literacy appeared, almost all of the Earth's literate population has lived within the World System; hence, the literate population of the Earth and the literate population of the World System have been almost perfectly synonymous.

*References*

*Abel W. 1980. Agricultural Fluctuations in Europe from the Thirteenth to the Twentieth Centuries.* New York: St. Martin's.

*Aghion P., and Howitt P. 1998. Endogenous Growth Theory.* Cambridge, MA: MIT Press.

*Bambach R. K. 1977.* Species Richness in Marine Benthic Habitats through the Phanerozoic. *Paleobiology* 3: 152–167.

*Bambach R. K., Knoll A. H., and Sepkoski J. J. 2002.* Anatomical and Ecological Constraints on Phanerozoic Animal Diversity in the Marine Realm. *Proceedings of the National Academy of Sciences* 99(10): 6854–6859.

*Benton M. J. 1995.* Diversification and Extinction in the History of Life. *Science* 268: 52–58.

*Boyd R., and Richerson P. J. 1996.* Why Culture is Common, but Cultural Evolution is Rare. *Proceedings of the British Academy* 88: 77–93.

*Braudel F. 1973. Capitalism and Material Life, 1400–1800.* New York: Harper and Row.

*Brett C. E., Hendy A. J. W., Bartholomew A. J., Bonelli J. R., Jr., and McLaughlin P. I. 2007.* Response of Shallow Marine Biotas to Sea-Level Fluctuations: A Review of Faunal Replacement and the Process of Habitat Tracking. *Palaios* 22: 228–244.

*Brett C. E., Ivany L. C., and Schopf K. M. 1996.* Coordinated Stasis: An Overview. *Palaeogeography, Palaeoclimatology, Palaeoecology* 127: 1–20.

*Bush A. M., and Bambach R. K. 2004.* Did Alpha Diversity Increase during the Phanerozoic? Lifting the Veils of Taphonomic, Latitudinal, and Environmental Biases. *Journal of Geology* 112: 625–642.

*Chandler T. 1987. Four Thousand Years of Urban Growth: An Historical Census.* Lewiston, NY: Edwin Mellen Press.

*Christian D. 2005. Maps of Time: An Introduction to Big History.* Berkeley, CA: University of California Press.

*Chu C. Y. C., and Lee R. D. 1994.* Famine, Revolt, and the Dynastic Cycle: Population Dynamics in Historic China. *Journal of Population Economics* 7: 351–378.

*Chubarov V. V. 1991.* The Middle Eastern Locomotive: The Developmental Pace of Technique and Technology in the Ancient World. *The Archaic Society: The Main Problems of Developmental Sociology.* Vol. 1 / Ed. by A. V. Korotayev and V. V. Chubarov, pp. 92–135. Moscow: Institute for History, Academy of Sciences, USSR. *In Russian* (Чубаров В. В. *Ближневосточный локомотив: Темпы развития техники и технологии в древнем мире. Архаическое общество: Узловые проблемы социологии развития.* Т. 1 / Ред. А. В. Коротаев, В. В. Чубаров, с. 92–135. М.: Ин-т истории АН СССР).

*Cohen J. E. 1995.* Population Growth and Earth’s Carrying Capacity. *Science* 269(5222): 341–346.

*Cornette J. L., and Lieberman B. S. 2004.* Random Walks in the History of Life. *Proceedings of the National Academy of Sciences* 101(1): 187–191.

*Durkheim E. 1991 [1893]. The Division of Labor in Society. Sociological Method.* Moscow: Nauka. *In Russian* (Дюркгейм Э. *О разделении общественного труда. Метод социологии. М.: Наука*).

*von Foerster H., Mora P., and Amiot L. 1960.* Doomsday: Friday, 13 November, A.D. 2026. *Science* 132: 1291–1295.

*Goldstone J. A. 1991. Revolution and Rebellion in the Early Modern World.* Berkeley, CA: University of California Press.

*Golosovsky M. 2010.* Hyperbolic Growth of the Human Population of the Earth: Analysis of Existing Models. *History & Mathematics: Processes and Models of Global Dynamics* / Ed. by L. Grinin, P. Herrmann, A. Korotayev, and A. Tausch, pp. 188–204. Volgograd: Uchitel.

*Grinin L. E. 2007a.* Problems in the Analysis of the Driving Forces of Historical Development: Social Progress and Social Evolution. *Philosophy of History: Problems and Prospects* / Ed. by Yu. I. Semenov, I. A. Gobozov, and L. E. Grinin, pp. 148–247. Moscow: KomKniga/URSS. *In Russian* (Гринин Л. Е. Проблемы анализа движущих сил исторического развития, общественного прогресса и социальной эволюции. *Философия истории: проблемы и перспективы* / Ред. Ю. И. Семенов, И. А. Гобозов, Л. Е. Гринин, с. 148–247. М.: КомКнига/URSS).

*Grinin L. E. 2007b***.** Industrial Revolutions as the Most Important Thresholds in History. *Man and Nature: Confrontation and Harmony.* Series ‘Socionatural History: The Genesis of Natural and Societal Crises in Russia’ / Ed. by E. S. Kulpin, pp. 191–221. Moscow: Publishing-Analytical Centre ‘Energy’. *In Russian* (Гри-нин Л. Е. Производственные революции как важнейшие рубежи истории. *Человек и природа: противостояние и гармония.* Серия «Социоестественная история. Генезис кризисов природы и общества в России» / Ред. Э. С. Кульпин,с. 191–221. М.: Издательско-аналитический центр «Энергия»).

*Grinin L. E. 2012. Macrohistory and Globalization.* Volgograd: Uchitel.

*Grinin L. E., Carneiro R. L., Korotayev A. V., and Spier F. (Eds.) 2011. Evolution: Cosmic, Biological, and Social.* Volgograd: Uchitel.

*Grinin L. E., and Korotayev A. V. 2006.* Political Development of the World System: A Formal Quantitative Analysis. *History & Mathematics: Historical Dynamics and Development of Complex Societies* / Ed. by P. Turchin, L. E. Grinin, V. C. de Munck, and A. V. Korotayev, pp. 63–114. Moscow: KomKniga.

*Grinin L. E., and Korotayev A. V. 2007a***.** Political Development of the World System: A Formal Quantitative Analysis. *History and Mathematics: Macrohistorical Dynamics of the Society and State* / Ed. by S. Yu. Malkov, L. E. Grinin, and A. V. Korotayev, pp. 49–101. Moscow: KomKniga. *In Russian* (Гринин Л. Е., Коротаев А. В. Политическое развитие Мир-Системы: формальный и количественный анализ. *История и Математика: макроисторическая динамика общества и государства* / Ред. С. Ю. Малков, Л. Е. Гринин, А. В.

Коротаев, с. 49–101. М.: КомКнига).

*Grinin L. E., and Korotayev A. V. 2007b.* Social Macroevolution and Historical Process. *Filosofiya i obschestvo* 2: 19–66; 3: 5–48; 4: 17–50. *In Russian* (Гринин Л. Е., Коротаев А. В. Социальная макроэволюция и исторический процесс. *Философия и общество* 2: 19–66; 3: 5–76; 4: 17–50).

*Grinin L. E., and Korotayev A. V. 2008.* Macroevolution and the World-System: New Facets of Conceptualization. *Istoriya i sovremennost* 1: 3–31. *In Russian* (Гринин Л. Е., Коротаев А. В. Макроэволюция и Мир-Система: новые грани концептуализации. *История и современность* 1: 3–31).

*Grinin L. E., and Korotayev A. V. 2009a.* Social Macroevolution: Growth of the World System Integrity and a System of Phase Transitions. *World Futures* 65(7): 477–506.

*Grinin L. E., and Korotayev A. V. 2009b. Social Macroevolution: Genesis and Transformations of the World System.* Moscow: LIBROKOM. *In Russian* (Гринин Л. Е., Коротаев А. В. *Социальная макроэволюция: Генезис и трансформации Мир-Системы.* М.: ЛИБРОКОМ).

*Grinin L. E., and Korotayev A. V. 2012. Cycles, Crises, and Traps of the Modern World System.* Moscow: URSS. *In Russian* (Гринин Л. Е, Коротаев А. В. *Циклы, кризисы, ловушки современной Мир-Системы.* М.: URSS).

*Grinin L. E., Korotayev A. V., and Malkov S. Yu. 2008.* Mathematical Models of Socio-Demographic Cycles and Escape from the Malthusian Trap. *Problems of Mathematical History: Mathematical Modeling of Historical Processes* / Ed. by G. G. Malinetsky, and A. V. Korotayev, pp. 78–117. Moscow: URSS. *In Russian* (Гринин Л. Е., Коротаев А. В., Малков С. Ю. Математические модели социально-демографических циклов и выхода из мальтузианской ловушки. Проблемы математической истории. *Математическое моделирование исторических процессов* / Ред. Г. Г. Малинецкий, А. В. Коротаев, с. 78–117. М.: URSS).

*Grinin L. E., Malkov S. Yu., Gusev V. A., and Korotayev A. V. 2009.* Possible Directions for Further Development of Socio-Demographic Cycle Theory and Mathematical Models of the Escape from the Malthusian Trap. *History & Mathematics: Processes & Models* / Ed. by S. Yu. Malkov, L. E. Grinin, and A. V. Korotayev, pp. 134–210. Moscow: URSS. *In Russian* (Гринин Л. Е., Малков С. Ю., Гусев В. А., Коротаев А. В. Некоторые возможные направления развития теории социально-демографических циклов и математические модели выхода из мальтузианской ловушки. *История и Математика: процессы и модели* / Ред. С. Ю. Малков, Л. Е. Гринин, А. В. Коротаев, с. 134–210. М.:

URSS).

*Grinin L. E., Markov A. V., and Korotayev A. V. 2008. Macroevolution in Biological and Social Systems.* Moscow: LKI. *In Russian* (Гринин Л. Е., Марков А. В., Коротаев А. В. *Макроэволюция в живой природе и обществе.* М.: ЛКИ).

*Grinin L. E., Markov A. V., and Korotayev A. V. 2009a.* Aromorphoses in Biological and Social Evolution: Some General Rules for Biological and Social Forms of Macroevolution. *Social Evolution & History* 8(2): 6–50.

*Grinin L. E., Markov A. V., and Korotayev A. V. 2009b.* Aromorphoses in Biological and Social Evolution: An Experiment Comparing Biological and Social Forms of Macroevolution. *Evolution: Cosmic, Biological, and Social* / Ed. by L. E. Grinin, A. V. Markov, and A. V. Korotayev, pp. 176–225. Moscow: LIBROCOM. *In Russian* (Гринин Л. Е., Марков А. В., Коротаев А. В. Ароморфозы в живой природе и обществе: опыт сравнения биологической и социальной форм макроэволюции. *Эволюция: космическая, биологическая, социальная* / Ред. Л. Е. Гринин, А. В. Марков, А. В. Коротаев, с. 176–225. М.: ЛИБРОКОМ).

*Grinin L. E., Markov A. V., and Korotayev A. V. 2011.* Biological and Social Aromorphoses: A Comparison between Two Forms of Macroevolution. *Evolution: Cosmic, Biological, and Social* / Ed. by L. E. Grinin, R. L. Carneiro, A. V. Korotayev, and F. Spier, pp. 162–211. Volgograd: Uchitel.

*Grinin L. E., Markov A. V., and Korotayev A. V. 2012.* Biological and Social Phases of Big History: Similarities and Differences of Evolutionary Principles and Mechanisms. *Evolution: A Big History Perspective* / Ed. by L. E. Grinin, A. V. Korotayev, and B. H. Rodrigue, pp. 158–198. Volgograd: Uchitel.

*Grossman G., and Helpman E. 1991. Innovation and Growth in the Global Economy.* Cambridge, MA: MIT Press.

*Gruebler A. 2006. Urbanization as Core Process of Global Change: The Last 1000 Years and Next 100.* Paper presented at the International Seminar 'Globalization as Evolutionary Process: Modeling, Simulating, and Forecasting Global Change', International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria, April 6–8.

*Hallpike C. R. 1986. Principles of Social Evolution.* Oxford: Clarendon.

*Heylighen F. 2011.* Conceptions of a Global Brain: An Historical Review. *Evolution: Cosmic, Biological, and Social* / Ed. by L. E. Grinin, R. L. Carneiro, A. V. Korotayev, and F. Spier, pp. 274–289. Volgograd: Uchitel.

*von Hoerner S. J. 1975.* Population Explosion and Interstellar Expansion. *Journal of the British Interplanetary Society* 28: 691–712.

*Jablonski D. 2005.* Mass Extinctions and Macroevolution. *Paleobiology* 31(2):

192–210.

*Jones C. I. 1995.* R&D-based Models of Economic Growth. *The Journal of Political Economy* 103: 759–784.

*Jones C. I. 2005.* The Shape of Production Functions and the Direction of Technical Change. *The Quarterly Journal of Economics* 120: 517–549.

*Kapitza S. P. 1999. How Many People have ever Lived, are Living, and will Live on the Earth.* Moscow: Nauka. *In Russian* (Капица С. П. *Сколько людей жило, живет и будет жить на земле.* М.: Наука).

*van Kessel-Hagesteijn R. 2009.* Dynamics in Political Centralization Processes: The Various Faces of 'Decline'. *International Symposium on Early State Formation Handbook,* pp. 46–63. Peking: National Academy of China.

*Komlos J., and Nefedov S. 2002.* A Compact Macromodel of Pre-Industrial Population Growth. *Historical Methods* 35: 92–94.

*Korotayev A. 2005.* A Compact Macromodel of World System Evolution. *Journal of World-Systems Research* 11(1): 79–93.

*Korotayev A. V. 2006. The Long-Term Political-Demographic Dynamics of Egypt: Cycles and Trends.* Moscow: Vostochnaya Literatura. *In Russian* (Коротаев А. В. *Долгосрочная политико-демографическая динамика Египта: циклы и тенденции.* М.: Восточная литература).

*Korotayev A. V. 2007.* Compact Mathematical Models of World System Development, and How They Can Help Us to Clarify Our Understanding of Globalization Processes. *Globalization as Evolutionary Process: Modeling Global Change* / Ed. by G. Modelski, T. Devezas, and W. R. Thompson, pp. 133–160. London: Routledge.

*Korotayev A. V. 2008.* Globalization and Mathematical Modeling of Global Development. *Hierarchy and Power in the History of Civilizations: Political Aspects of Modernity* / Ed. by L. E. Grinin, D. D. Beliaev, and A. V. Korotayev, pp. 225–240. Moscow: LIBROCOM/URSS.

*Korotayev A. V. 2009.* Compact Mathematical Models of the World System Development and Their Applicability to the Development of Local Solutions in Third World Countries. *Systemic Development: Local Solutions in a Global Environment* / Ed. by J. Sheffield, pp. 103−116. Litchfield Park, AZ: ISCE Publishing.

*Korotayev A. V. 2012.* Globalization and Mathematical Modeling of Global Development. *Globalistics and Globalization Studies* / Ed. by L. Grinin, I. Ilyin, and A. Korotayev, pp. 148–158. Moscow – Volgograd: Moscow University – Uchitel.

*Korotayev A. V., and Khaltourina D. A. 2006. Introduction to Social*

*Macrodynamics: Secular Cycles and Millennial Trends in Africa.* Moscow: URSS.

*Korotayev A. V., Khaltourina D. A., and Bogevolnov J. V. 2010. Laws of History. Secular Cycles and Millennial Trends. Demography. Economy. Wars.* Moscow: URSS. *In Russian* (Коротаев А. В., Халтурина Д. А., Божевольнов Ю. В. *Законы истории. Вековые циклы и тысячелетние тренды. Демография. Экономика. Войны.* М.: URSS).

*Korotayev A. V., Khaltourina D. A., Malkov A. S., Bogevolnov J. V., Kobzeva S. V., and Zinkina J. V. 2010***.** *Laws of History: Mathematical Modeling and Forecasting World and Regional Development.* Moscow: URSS. *In Russian* (Коротаев А. В., Халтурина Д. А., Малков А. С., Божевольнов Ю. В., Кобзева С. В., Зинькина Ю. В. *Законы истории. Математическое моделирование и прогнозирование мирового и регионального развития.* М.: URSS).

*Korotayev A. V., Komarova N. L., and Khaltourina D. A. 2007. Laws of History: Secular Cycles and Millennial Trends.* Moscow: URSS. *In Russian* (Коротаев А. В., Комарова Н. Л., Халтурина Д. А. *Законы истории. Вековые циклы и тысячелетние тренды.* М.: URSS).

*Korotayev A. V., and Malkov S. Yu. 2012.* Mathematical Models of the World-System Development. *Routledge Handbook of World-Systems Analysis* / Ed. by S. Babones, and C. Chase-Dunn, pp. 158–161. London: Routledge.

*Korotayev A. V., Malkov A. S., and Khaltourina D. A. 2006a. Introduction to Social Macrodynamics: Compact Macromodels of the World System Growth.* Moscow: URSS.

*Korotayev A. V., Malkov A. S., and Khaltourina D. A. 2006b. Introduction to Social Macrodynamics: Secular Cycles and Millennial Trends.* Moscow: URSS.

*Kremer M. 1993.* Population Growth and Technological Change: One Million B.C. to 1990. *The Quarterly Journal of Economics* 108: 681–716.

*Kurdyumov S. P. (Ed.) 1999. Blow-up Regimes.* Moscow: Nauka. *In Russian* (Курдюмов С. П. (Ред.). *Режимы с обострением.* М.: Наука).

*Kuznets S. 1960.* Population Change and Aggregate Output. *Demographic and Economic Change in Developed Countries*, pp. 324–340. Princeton, NY: Princeton University Press.

*Laland K. N., Odling-Smee F. J., and Feldman M. W. 1999.* Evolutionary Consequences of Niche Construction and Their Implications for Ecology. *Proceedings of the National Academy of Sciences* 96(18): 10242–10247.

*Lekevičius E. 2009.* On Some Analogues between the Evolution of Ecosystems and Economic Development: From A. Smith and C. Darwin to the Newest Ideas. *Evolution: Cosmic, Biological, and Social* / Ed. by L. E. Grinin, A. V. Markov, and

A. V. Korotayev, pp. 226–259. Moscow: LIBROKOM. *In Russian* (Лекявичюс Э. О некоторых аналогиях между эволюцией экосистем и развитием экономики: от А. Смита и Ч. Дарвина до новейших идей. *Эволюция: космическая, биологическая, социальная* / Ред. Л. Е. Гринин, А. В. Марков, А. В. Коротаев, с. 226–259. М.: ЛИБРОКОМ).

*Lekevičius E. 2011.* Ecological Darwinism or Preliminary Answers to Some Crucial Though Seldom Asked Questions. *Evolution: Cosmic, Biological, and Social* / Ed. by L. E. Grinin, R. L. Carneiro, A. V. Korotayev, and F. Spier, pp. 101–121. Volgograd: Uchitel.

*Levinson D., and Malone M. 1980. Toward Explaining Human Culture.* New Haven, CT: HRAF Press.

*Maddison A. 2001. Monitoring the World Economy: A Millennial Perspective.* Paris: OECD.

*Magurran A. E. 1988. Ecological Diversity and Its Measurement.* Princeton, NY: Princeton University Press.

*Malthus T. 1978 [1798]. Population: The First Essay.* Ann Arbor, MI: University of Michigan Press.

*Markov A. V. 2001.* Dynamics of the Marine Faunal Diversity in the Phanerozoic: A New Approach. *Paleontological Journal* 35: 1–9.

*Markov A. V. 2002.* Mechanisms Responsible for the Increase in the Taxonomic Diversity in the Phanerozoic Marine Biota. *Paleontological Journal* 36: 121–130.

*Markov A. V., and Korotayev A. V. 2007.* Phanerozoic Marine Biodiversity Follows a Hyperbolic Trend. *Palaeoworld* 16: 311–318.

*Markov A. V., and Korotayev A. V. 2008.* Hyperbolic Growth of Phanerozoic Marine and Continental Biodiversity. *Zhurnal obshchey biologii* 3: 175–194. *In Russian* (Марков А. В., Коротаев А. В. Гиперболический рост разнообразия морской и континентальной биот фанерозоя. *Журнал общей биологии* 3: 175–194).

*Markov A. V., and Naymark E. B. 2009.* On Some of the Newest Achievements in Evolutionary Biology. *Evolution: Cosmic, Biological, and Social* / Ed. by L. E. Grinin, A. V. Markov, and A. V. Korotayev, pp. 306–363. Moscow: LIBROCOM. *In Russian* (Марков А. В., Наймарк Е. Б. О некоторых новейших достижениях эволюционной биологии. *Эволюция: космическая, биологическая, социальная* / Ред. Л. Е. Гринин, А. В. Марков, А. В. Коротаев, с. 306–363. М.: ЛИБРОКОМ).

*McEvedy C., and Jones R. 1978. Atlas of World Population History.* New York: Facts on File.

*Meliantsev V. A. 2004.* Russia's Comparative Economic Development in the Long

Run. *Social Evolution & History* 3(1): 106–136

*Mesoudi A., Whiten A., and Laland K. 2006.* Towards a Unified Science of Cultural Evolution. *Behavioral and Brain Sciences* 29: 329–383.

*Modelski G. 2003. World Cities: –3000 to 2000.* Washington: Faros2000.

*Naroll R., and Divale W. T. 1976.* Natural Selection in Cultural Evolution: Warfare versus Peaceful Diffusion. *American Ethnologist* 3: 97–128.

*Nefedov S. A. 2004.* A Model of Demographic Cycles in Traditional Societies: The Case of Ancient China. *Social Evolution & History* 3(1): 69–80.

*Podlazov A. V. 2004.* Theory of the Global Demographic Process. *Mathematical Modeling of Social and Economic Dynamic* / Ed. by M. G. Dmitriev, and A. P. Petrov, pp. 269–272. Moscow: Russian State Social University.

*Powell M. G., and Kowalewski M. 2002.* Increase in Evenness and Sampled Alpha Diversity through the Phanerozoic: Comparison of Early Paleozoic and Cenozoic Marine Fossil Assemblages. *Geology* 30(4): 331–334.

*Raup D. M., Gould S. J., Schopf T. J. M., and Simberloff D. S. 1973.* Stochastic Models of Phylogeny and the Evolution of Diversity. *Journal of Geology* 81(5): 525–542.

*Raup D. M., and Sepkoski J. J. 1984.* Periodicity of Extinctions in the Geologic Past. *Proceedings of the National Academy of Sciences* 81(3): 801–805.

*Reeve H. K., and Hölldobler B. 2007.* The Emergence of a Superorganism through Intergroup Competition. *Proceedings of the National Academy of Sciences of the USA* 104(23): 9736−9740.

*Reznikova Zh. 2011.* Evolutionary and Behavioural Aspects of Altruism in Animal Communities: Is There Room for Intelligence? *Evolution: Cosmic, Biological, and Social* / Ed. by L. E. Grinin, R. L. Carneiro, A. V. Korotayev, and F. Spier, pp. 162–211. Volgograd: Uchitel.

*Robson S. K., and Traniello J. F. A. 2002.* Transient Division of Labour and Behavioral Specialization in the Ant Formica Schaufussi. *Naturwissenschaften* 89: 128–131.

*Rohde R. A., and Muller R. A. 2005.* Cycles in Fossil Diversity. *Nature* 434(7030): 147–148.

*Ryabko B., and Reznikova Zh. 2009.* The Use of Ideas of Information Theory for Studying 'Language' and Intelligence in Ants. *Entropy* 11(4): 836–853.

*Sepkoski J. J. 1988.* Alpha, Beta or Gamma: Where Does All the Diversity Go? *Paleobiology* 14: 221–234.

*Sepkoski J. J. 1991a.* Population Biology Models in Macroevolution. *Analytical Paleobiology. Short Courses in Paleontology*. Vol. 4 / Ed. by N. L. Gilinsky, and

P. W. Signor, pp. 136–156. Knoxville, TN: The Paleontological Society.

*Sepkoski J. J. 1991b.* Diversity in the Phanerozoic Oceans: A Partisan Review. *The Unity of Evolutionary Biology* / Ed. by E. C. Dudley, pp. 210–326. Portland, OR: Dioscorides Press.

*Sepkoski J. J. 1992.* Phylogenetic and Ecologic Patterns in the Phanerozoic History of Marine Biodiversity. *Systematics, Ecology and the Biodiversity Crisis* / Ed. by N. Eldredge, pp. 77–100. New York: Columbia University Press.

*Sepkoski J. J. 1994.* Limits to Randomness in Paleobiologic Models: The Case of Phanerozoic Species Diversity. *Acta Palaeontologica Polonica* 38(3–4): 174–198.

*Sepkoski J. J., Bambach R. K., Raup D. M., and Valentine J. W. 1981.* Phanerozoic Marine Diversity and the Fossil Record. *Nature* 293: 435–437.

*Severtsov A. S. 1987.* Criteria and Conditions for the Appearance of Aromorphic Organization. *Evolution and Biocenotic Crises* / Ed. by L. P. Tatarinov, and A. P. Rasnitsyn, pp. 64–76. Moscow: Nauka. *In Russian* (Северцов А. С. Критерии и условия возникновения ароморфной организации. *Эволюция и биоценотические кризисы* / Ред. Л. П. Татаринов, А. П. Расницын, с. 64–76. М.: Наука).

*Shmal'gauzen I. I. 1969. The Problems of Darwinism.* Leningrad: Nauka. *In Russian* (Шмальгаузен И. И. *Проблемы дарвинизма.* Л.: Наука).

*Simon J. 1977. The Economics of Population Growth.* Princeton, NY: Princeton University Press.

*Simon J. 2000. The Great Breakthrough and Its Cause.* Ann Arbor, MI: University of Michigan Press.

*Solé R. V., Montoya J. M., and Erwin D. H. 2002.* Recovery after Mass Extinction: Evolutionary Assembly in Large-Scale Biosphere Dynamics. *Philosophical Transactions of the Royal Society of London, B* 357: 697–707.

*Spencer H. 1898. Principles of Sociology. Complete Work.* Vol. 1. St. Petersburg: T-vo I. D. Sytina, Otd. N. A. Rubakina. *In Russian* (Спенсер Г. *Основания социологии. Соч.* Т. 1. СПб.: Т-во И. Д. Сытина, Отд. Н. А. Рубакина).

*Taagapera R. 1976.* Crisis around 2005 A.D.? A Technology-Population Interaction Model. *General Systems* 21: 137–138.

*Taagapera R. 1979.* People, Skills, and Resources: An Interaction Model for World Population Growth. *Technological Forecasting and Social Change* 13: 13–30.

*Tsirel S. V. 2004.* On the Possible Reasons for the Hyperexponential Growth of the Earth Population. *Mathematical Modeling of Social and Economic Dynamics* / Ed. by M. G. Dmitriev, and A. P. Petrov, pp. 367–369. Moscow: Russian State Social University.

*Turchin P. 2003. Historical Dynamics: Why States Rise and Fall.* Princeton, NY: Princeton University Press.

*Turchin P. 2005a.* Dynamical Feedbacks between Population Growth and Sociopolitical Instability in Agrarian States. *Structure and Dynamics* 1(1). URL: http://eschol arship.org/uc/item/0d17g8g9.

*Turchin P. 2005b. War and Peace and War: Life Cycles of Imperial Nations.* New York: Pi Press.

*Turchin P., and Korotayev A. 2006***.** Population Density and Warfare: A Reconsideration. *Social Evolution & History* 5(2): 121–158.

*Turchin P., and Nefedov S. 2009. Secular Cycles.* Princeton, NY: Princeton University Press.

*UN Population Division. 2014. United Nations Population Division database.* URL: http://www.un.org/esa/population.

*US Bureau of the Census. 2013. World Population Information.* URL: http://www.census.gov/ipc /www/world.html.

*Usher D. 1989.* The Dynastic Cycle and the Stationary State. *The American Economic Review* 79: 1031–1044.

*Wagner P. J., Kosnik M. A., and Lidgard S. 2006.* Abundance Distributions Imply Elevated Complexity of Post-Paleozoic Marine Ecosystems. *Science* 314: 1289–1292.

*World Bank. 2013. World Development Indicators Online.* URL: http://data.world bank.org/indicator.

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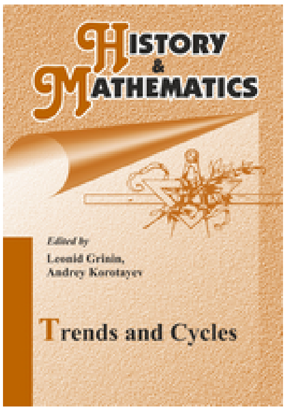
# A Trap At The Escape From The Trap? Some Demographic Structural Factors Of Political

# Instability In Modernizing Social Systems



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*Abstract*
The escape from the 'Malthusian trap' is shown to tend to generate in a rather systematic way quite serious political upheavals. Some demographic structural mechanisms that generate such upheavals have been analyzed, which has made it possible to develop a mathematical model of the respective processes.
The forecast of political instability in Sub-Saharan African countries in 2015–2050 produced on the basis of this model is presented.

*Keywords:* modernization, instability, Malthusian trap, mathematical modeling, youth bulge, urbanization, Africa, demographic dynamics, demographic transition, political dynamics, political demography. – *This research has been supported by the Russian Science Foundation (Project No 14-11-00634)*

*Malthusian trap as a factor of political instability*
What is that trap which we mention in the title of this article (and at whose escape we claim another trap to be detected)? It is the so-called 'Malthusian trap'.

The Malthusian trap[2] is a rather typical for pre-industrial societies situation when the growth of output (as it is accompanied by a faster demographic growth) does not lead in the long-range perspective to the increase in per capita output and the improvement of living conditions of the majority of population that remains close to the bare survival level (see, *e.g.*, Malthus 1798, 1978 [1798]; Artzrouni and Komlos 1985; Steinmann and Komlos 1988; Komlos and Artzrouni 1990; Steinmann, Prskawetz, and Feichtinger 1998; Wood 1998; Kögel and Prskawetz 2001; Grinin, Korotayev, and Malkov 2008; Grinin and Korotayev 2009; Grinin *et al.* 2009; Grinin 2010).

In complex pre-industrial societies the Malthusian trap was one of the main generators of state breakdowns (see, *e.g.*, Korotayev and Khaltourina 2006; Korotayev, Malkov, and Khaltourina 2006b; Chu and Lee 1994; Nefedov 2004; Turchin 2003, 2005a, 2005b; Turchin and Korotayev 2006; Turchin and Nefedov 2009; Usher 1989; Grinin and Korotayev 2009; Grinin, Korotayev, and Malkov 2008; Grinin *et al.* 2009; Grinin 2007; Korotayev 2006; Korotayev, Komorova, and Khaltourina 2007; Kulpin 1990; Malkov 2002, 2003, 2004; S. Malkov and A. Malkov 2000; S. Malkov, Kovalyov, and A. Malkov 2000; Malkov *et al.* 2002; Malkov, Selunskaya, and Sergeyev 2005; Malkov and Sergeyev 2002, 2004a, 2004b; Mugruzin 1986, 1994; Nefedov 1999–2010; Nefedov and Turchin 2007; Turchin 2007; van Kessel-Hagesteijn 2009).

A typical example is provided by the last (Qing) of the ‘secular’ (see Korotayev, Malkov, and Khaltourina 2006b; Turchin and Nefedov 2009) cycles of Chinese political-demographic dynamics. In 1700–1850 China managed to achieve rather impressive economic results (due to, say, introduction of some New World crops [first of all, maize and sweet potatoes], development of new varieties of previously known cultivated plants, agricultural labor intensification, land reclamation, *etc.* [Ho 1955; 1959: 173–174, 180, 185–189; Lee 1982; Bray 1984: 452, 601; Perkins 1969: 39–40; Dikarev 1991: 69–70; Fairbank 1992: 169; Lavely and Wong 1998: 725–726; Lee and Wang 1999: 37–40; Mote 1999: 750, 942; Nefedov 2000a: 17; Myers and Wang 2002: 599, 634–636; Rowe 2002: 479; Zelin 2002: 216–218; van Kessel-Hagesteijn 2009]). As a result of these innovations the carrying capacity of land during this cycle was raised to a radically new level, which also resulted in a rather significant growth of the Chinese GDP.

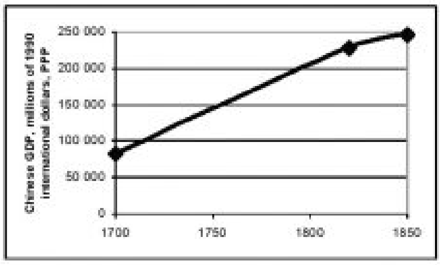


**Fig. 1.** Economic macrodynamics of China, 1700–1850 (GDP, millions of 1990 international dollars, purchasing power parities)
*Data source*: Maddison 2001, 2010.

Fig. 1. Economic macrodynamics of China, 1700–1850 (GDP, millions of 1990 international dollars, purchasing power parities) Data source: Maddison 2001, 2010.

Thus, according to Maddison's (2001, 2010) estimations, between 1700 and 1850 the GDP of China grew almost threefold (see Fig. 1).

However, the Chinese population grew during the same period of time more than fourfold (see Fig. 2).

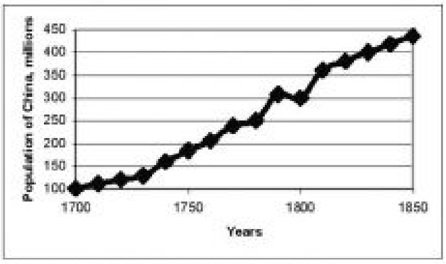


**Fig. 2.** Population of China, millions, 1700–1850
*Note*: estimates of Zhao and Xie (1988: 539–540).

Fig. 2. Population of China, millions, 1700–1850 Note: estimates of Zhao and Xie (1988: 539–540).

As a result, by 1850 we observe a rather significant decline of per capita GDP (see Fig. 3).

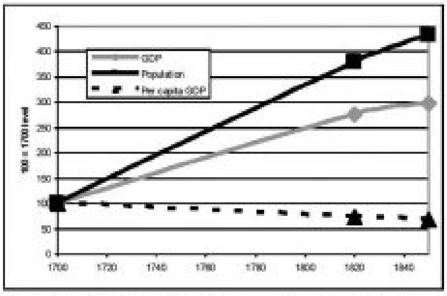


**Fig. 3.** Relative dynamics of GDP, population, and per capita GDP in Qing China, 1700–1850 (100 = 1700 level)

Fig. 3. Relative dynamics of GDP, population, and per capita GDP in Qing China, 1700–1850 (100 = 1700 level)

The decline in the level of life of the majority of Chinese (mainly resultant just from the point that the Chinese population growth rates exceeded the rates of economic growth) can be traced on the basis of a significant number of independent data series. For example, Fig. 4 reflects the dynamics of average real daily wages of unskilled workers in this country. As we see, quite predictably, as a result of population growth rates being higher than GDP growth rates, the average real daily wages (that were not high at all even at the beginning of the respective period [see Korotayev and Khaltourina 2006 for comparisons]) dropped to the level of bare physiological survival by the end of the period in question.

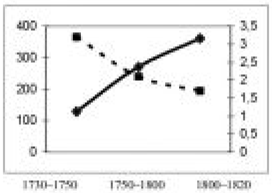


**Fig. 4.** Population and food consumption in China in the Qing period

*Note:* - - ■ - - consumption (daily wages, liters of rice); —♦— population (millions).

*Source:* Adopted from Nefedov 2003: 5. The data on daily wages are from Chao 1986: 218–219. The data on population are from Zhao and Xie 1988: 541–542.

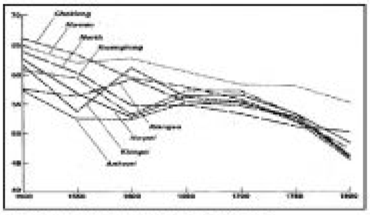


**Fig. 5.** Regional life expectancy from 1500 to 1800

*Note:* "The figures indicate the average age at death of the population already having reached the Chinese age of 15" (Heijdra 1998: 437); hence, the present diagram does not take into account those numerous representatives of respective populations who died before reaching this age. It is perfectly clear that, if this part of the population were taken into account, the values of the average age at death would be radically lower. However, the present diagram gives important information on the relative dynamics of this very important indicator.

Population growth rate being higher than the growth rate of GDP, Qing China experienced a catastrophic decline in the level of life of the majority of Chinese population, which is confirmed by the data of Chinese genealogies (*chia-p'u*) (see Fig. 5).

It worth stressing that in this case we are dealing with a really mass source (for example, Fig. 5 was compiled on the basis of several hundred thousand Chinese genealogies). It also appears necessary to take into account the point that representatives of really low class strata had rather poor chances to get into the abovementioned genealogies. Thus, the data in Fig. 5 reflects the dynamics of the level of life not of the real low class strata, but rather of the Qing 'middle classes', whose members were represented in these genealogies on a really mass scale.

As we see, at the beginning of the Qing cycle the average age at death among the middle strata of the Chinese population was rather high – 55–60 years; however, by the end of the period in question the value of the respective indicator falls to explicitly low values (around 45 years), whereas it seems appropriate to emphasize that we are not dealing here with the lowest strata of the Chinese population. Another impressive feature is a striking synchronicity of the decline of the average age at death in various regions of China in the course of the Qing sociodemographic cycle.

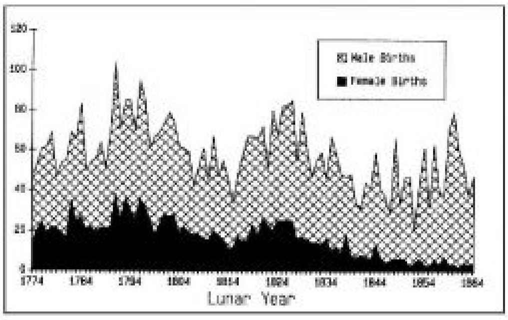


**Fig. 6.** Crude birth rates in Daoyi, 1774–1864 (per 1,000 married women aged 15–45)

*Source:* Lee, Campbell, and Tan 1992: 164, fig. 5.5.

The fact that the excess of demographic growth rates over GDP growth rates led in Qing China to a catastrophic decline in the level of life of the majority of population is confirmed by the data on dynamics of female infanticide (see Fig. 6).

Fig. 6 displays the results of processing of data taken from one of the Qing registration offices that registered births of both boys and girls. As we see, even in the beginning of the period covered by Fig. 6 the situation was far from problem-free – the office used to register just about 5 new-born girls per 10 new-born boys. However, by the late 1840s the situation became simply catastrophic – the office tended to register 1–2 new-born girls per 10 new-born boys.

It appears necessary to note that the historical economic research in this field has revealed for the Qing China the presence of rather strong and significant correlations between the levels of prices of basic food commodities and the levels of female infanticide (see, *e.g.*, Lee, Campbell, and Tan 1992: 158–175).
This, of course, suggests that the catastrophic growth of female infanticide was connected with the catastrophic decline of the living standard of the Chinese population majority.[3]

The catastrophic decline of the majority's level of life in China quite naturally led to the growth of dissatisfaction with the government, which in 1850–1870 produced a series of rebellions (the Taiping Rebellion was the largest among them [see, *e.g.*, Ilyushechkin 1967; Larin 1986; Nepomnin 2005: 395–444; Perkins 1969: 204; Kuhn 1978; Liu 1978 *etc.*]); this was apparently the bloodiest internal political collapse in the history of the humankind with the total number of dead being estimated as high as 118 (one hundred and eighteen!) million people (Huang 2002: 528). It worth noting that the majority of them died not as a result of direct violence, but because of diseases, famine, floods, *etc*. that took place in direct connection with the abovementioned events. The most destructive results were produced by the break of the dams by the Yellow River in 1853. As a result the great Chinese river changed its course (before these events it flew to the ocean south of the Shandung Peninsular, and afterwards it began to flow north of it), and a large part of densely populated Northern China was literally washed down. Numerous people died directly as a result of the flood, still more were left without sustenance, had to fled to the cities where the Qing government totally exhausted by the Taiping War had no resources to provide them with food. As a result, millions of undernourished people died of diseases and famine (see, *e.g.*, Kuhn 1978 for more details).

It should be emphasized that even the catastrophic change of the Yellow River course had evident Malthusian causes. The point is that in the preceding period the growing relative overpopulation of the Yellow River valley led to the increasing cultivation of the marginal lands upstream. This resulted in the acceleration of soil erosion and, consequently, the increasing silting of the Yellow River bottom; the bottom was rising more and more that increasingly raised the threat of floods. A whole system of counter-flood dams was built in order to counteract this threat – naturally, their height grew with the rise of the Yellow River bottom. As a result, by the beginning of the Taiping Rebellion the great Chinese river flew in its lower course well above the level of the North Chinese Plain, and in order to prevent its breaking the dams enormous (and constantly growing) resources were needed. After the Taiping rebels[4] captured the Chinese 'breadbasket' in the Lower Yangtze region, the revenues of the Qing budget shrank in the most catastrophic way; this was accompanied by an impetuous increase in military expenses that were necessary to counteract the deadly Taiping onslaught. As a result, the Qing government failed to secure the necessary (and very costly) support of the extremely complex counter-flood system, and the catastrophic break of the dams by the Yellow River became inevitable (see Korotayev, Malkov, and Khaltourina 2006b: ch. 2 for more details).

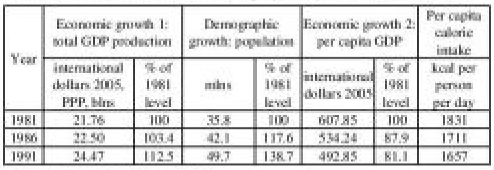
Note that Malthus himself considered warfare (including, naturally, internal warfare) as one of the most important results of overpopulation (in addition to epidemics and famines). What is more, he regarded wars, epidemics, and famines (and all of these were observed in China in 1850–1870) as so-called ‘positive checks’ that checked overpopulation in pre-industrial systems (Malthus 1978 [1798]). Thus, in pre-industrial societies bloody political upheavals frequently turned out to be a result of the respective social systems being caught in the Malthusian trap.

By now the students of social systems entrapped in the Malthusian trap have a rather significant number of mathematical models of political-demographic dynamics of such social systems describing the development of bloody political upheavals at the phase of socio-demographic collapse of pre-industrial political-demographic cycles (see, *e.g.*, Korotayev and Khaltourina 2006; Korotayev, Malkov, and Khaltourina 2006b; Usher 1989; Chu and Lee 1994; Malkov 2009; Komlos and Nefedov 2002; Turchin 2003, 2005a, 2005b; Nefedov 2004; Turchin and Nefedov 2009; Turchin and Korotayev 2006 *etc.*).

Demographic transition and the increase in agricultural productivity due to major technological advances in the recent centuries (see, *e.g.*, Grinin 2006) allowed most states to escape the Malthusian trap. The first phase of the demographic transition is characterized by a decline in mortality due to improved nutrition, sanitation, advancement and spread of modern medical technologies, *etc*. This leads to the acceleration of population growth. In the second phase of demographic transition, the development of medicine in combination with other processes (especially with mass education among women) leads to a widespread use of family planning technologies and, as a result, to a decrease of population growth rates (see, *e.g.*, Chesnais 1992; Korotayev, Malkov, and Khaltourina 2006a).

However, these modernization processes started later in Sub-Saharan Africa than in the rest of the world; and even in the recent decades the Malthusian trap tended to produce state breakdowns in this region.

Table 1. Ethiopian economic-demographic dynamics, 1981–1991



| Year | Economic growth 1: total GDP production | | Demographic growth: population | | Economic growth 2: per capita GDP | | Per capita calorie intake |
|---|---|---|---|---|---|---|---|
| | international dollars 2005, PPP, blns | % of 1981 level | mlns | % of 1981 level | international dollars 2005 | % of 1981 level | kcal per person per day |
| 1981 | 21.76 | 100 | 35.8 | 100 | 607.85 | 100 | 1831 |
| 1986 | 22.50 | 103.4 | 42.1 | 117.6 | 534.24 | 87.9 | 1711 |
| 1991 | 24.47 | 112.5 | 49.7 | 138.7 | 492.85 | 81.1 | 1657 |

*Sources*: World Bank 2014; FAO 2014.

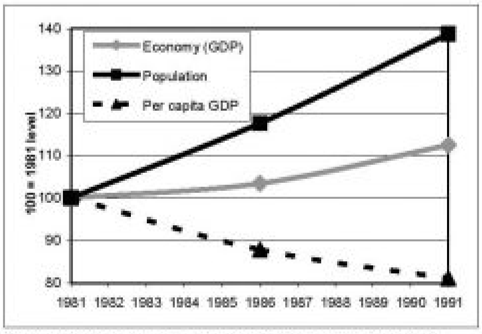


Fig. 7. Ethiopian economic-demographic dynamics, 1981–1991

For example, in the period preceding the fall of Mengistu Haile Mariam's regime, from 1981 to 1991, Ethiopia's GDP grew by 12.5 %, but during the same period the population grew by 40 %. As a result, GDP per capita fell from very low $608 to catastrophic $500. Another dramatic fall occurred in per capita calorie intake: 1831 kcal/day in 1981 was already very low, 1657 in 1991 was below physiological minimum (see Table 1).

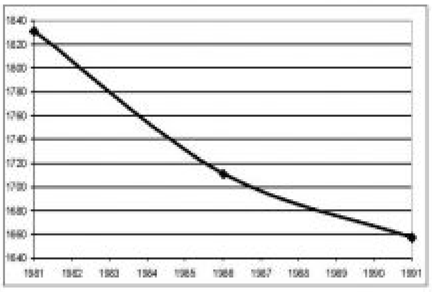


Fig. 8. Per capita food consumption, Ethiopia, 1981–1991, kcal/day

Such a low level of per capita food consumption means that a large part of a country's population is on the edge of serious starvation. In this situation, many inhabitants of this country might choose joining rebels (or bandits; in fact, as it is well known that rebels could be quite easily transformed into bandits, and *vice versa*). It can be quite a rational choice when continuation of usual ways of obtaining subsistence means an almost unavoidable hungry death, whereas joining rebels/bandits gives at least some realistic survival chances (see Korotayev and Khaltourina 2006 for more details). We do not say that this was the only cause of the fall of Mengistu Haile Mariam's regime, but we believe that this factor definitely contributed to this fall.

### *Some Features of Political-Demographic Dynamics of* Modernizing Systems

Against this background it appears interesting to consider a few cases of major political upheavals in recent decades.

### *Albania – Sociopolitical Collapse of 1997*

In 1997 Albania was swept by a wave of violent riots caused by the collapse of financial pyramids, as a result of which hundreds thousand Albanians lost all their savings. As is well known, many postsocialist European countries confronted this sort of problem (like the famous collapse of the MMM pyramid in Russia), but nowhere did this lead to a sociopolitical collapse comparable with the Albanian one:

*By early March 1997, Albania was in chaos… The army and police had mostly deserted. Armories had been looted…, evacuation of foreign nationals and mass emigration of Albanians to Italy began. The government's authority… had evaporated. When Tirana fell into civil disorder in late March, the government resigned… Some 2,000 people were killed… Almost one million weapons were looted… Large parts of the country were… outside of the government's control* (Jarvis 1999: 18).

The order in the country was only restored after the deployment of foreign (first of all, Italian) troops (*Ibid.:* 17). With a view to what we have already considered in the previous section, it appears rather seductive to suppose a certain 'Malthusian' component in the above-described events. Indeed, in the 1960s – 1990s Albania was the poorest European country with anomalously high (by European standards) birth and fertility rates (see, *e.g.*, Korotayev *et al.* 2010). Within such a context there seem to be all the possible grounds to expect the development of a classical Malthusian scenario: population growing faster than output – decline of per capita food consumption to the level of bare survival (or even below) – social explosion.

Against this background it appears interesting to consider the actual dynamics of per capita food consumption in Albania in the three decades preceding the sociopolitical collapse of 1997 (see Fig. 9).

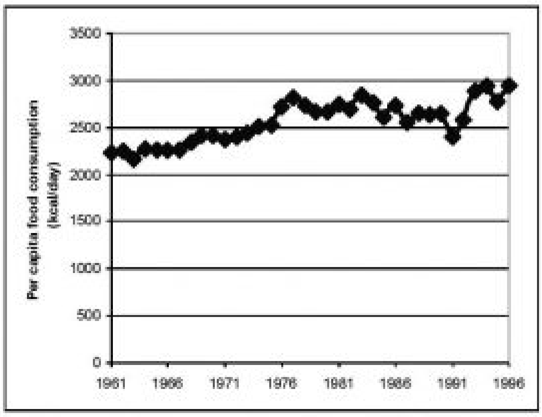


**Fig. 9.** Per capita food consumption in Albania, 1961–1996, kcal/day
*Data source*: FAO 2014.

As we see, for the period in question the dynamics of this indicator in Albania turned out to be almost contrary to the ones predicted by the Malthusian scenario. Still in the early 1960s in Albania the problem of malnutrition was very serious and the average per capita food consumption was below the norm of 2300–2400 kcal/day recommended by the WHO (see, *e.g.,* Naiken 2002).

However, in the 1960s and 1970s Albania managed to achieve evident successes in the solution of the food problem; in the late 1960s – early 1970s in this country the per capita food consumption exceeded the norm recommended by the WHO –

and afterwards it has never dropped below it. In the late 1970s and early 1980s the growth rate of this indicator slowed down, and in 1983–1991 a certain trend towards its decline was observed, which, of course, reflects very serious economic difficulties that were experienced by Albania in the last years of the 'communist' period of its history (see, *e.g.*, Sandstrom and Sjöberg 1991). However, even in 1991 (the hardest year in Albania) per capita food consumption did not drop below the norm recommended by the WHO. On the other hand, after 1991 Albania managed to achieve new successes in solving the food problem, and in 1993–1996 per capita food consumption in Albania reached record values for the whole Albanian history; by 1997 it was closer to what would be more appropriately called 'overeating' rather than 'undernourishment' level.

In any case, we may maintain with a high degree of confidence that with respect to Albania in 1961–1997 it appear impossible to speak about anything like a drop of per capita food consumption to the level of bare survival as a result of the population growing faster than output. It appears much more appropriate to say that these were precisely those years when Albania managed to escape quite successfully from the Malthusian trap.[5]

### *South Korea – The 1980 Kwangju Uprising*

After the end of the Korean War the largest popular uprising in South Korea took place in 1980 in the city of Kwangju (with 300 thousand participants, about 2000 dead, 5 divisions of regular army taking part in the suppression of the rebellion, *etc*.). This uprising was accompanied by a series of popular riots in neighboring cities (Lewis 2002).

Against this background, the dynamics of per capita food consumption in South Korea in the two decades preceding the abovementioned popular rebellion looks rather noteworthy (see Fig. 10).

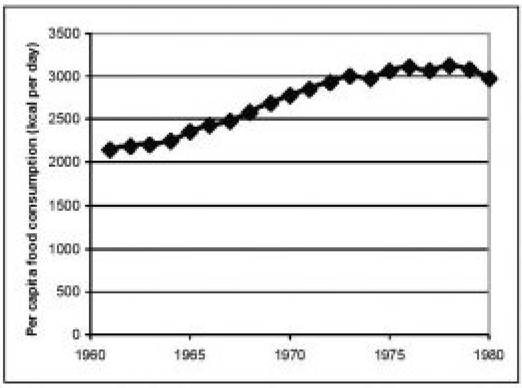


**Fig. 10.** Per capita food consumption in South Korea, 1961–1980, kcal/day

As we see, South Korea was another country that in the early 1960s encountered the undernourishment problem, the average per capita food consumption being below the norm recommended by the WHO. On the other hand, this was another country that in the 1960s and the early 1970s managed to achieve very noticeable achievements in solving the food problem; note that these achievements were even more considerable than in Albania, it was already in the mid-1960s that the average per capita food consumption in this country exceeded the norm recommended by the WHO (and it has never gone below that level afterwards). After 1973 the growth rate of this indicator in South Korea decreased, and in the late 1970s its certain (though quite insignificant) decline was observed. It does not seem to be a coincidence that this occurred simultaneously with the start of the period of an especially rapid growth of the South Korean economy (the so-called 'Korean economic miracle') when an unusually high proportion of the South Korean GDP was used for the gross capital formation purposes (see, *e.g.*, Akaev 2010); hence, an unusually low GDP share was left for the consumption purposes. In the meantime, it appears necessary to stress that, notwithstanding some (incidentally, very small) decline of the per capita food consumption in the late 1970s, the value of this indicator remained at a very high (about 3000 kcal per day) level by the start of the abovementioned popular rebellion.

In any case, with respect to South Korea in 1961–1980 we again get across the case when it is impossible to note any fall of per capita food consumption to the level of bare survival as a result of the population growth rates exceeding the output growth rates. We rather get across one more case when a social system escaped rather successfully from the Malthusian trap just in the decades preceding a social explosion.

### *Egypt – 1977 'Bread Riots'*

The largest political unrest in Egypt after 1952 took place in 1977 (the so-called 'Bread Riots'). The participants were chanting *Yā batl al-`ubūr! Fēn al-futūr?* 'Hero of the Crossing, where is our breakfast?' (addressing President Sadat).

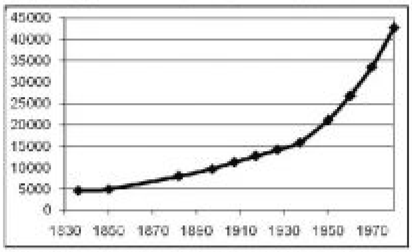


**Fig. 11.** Egyptian population dynamics, thousands of people, 1836–1989

*Data sources: for 1950–2005:* Maddison 2001, 2010; U.S. Bureau of the Census 2010; World Bank 2014; *for 1897–1950:* Craig 1917; Cleveland 1936: 7; Nimiq 1952; McCarthy 1976: 31–3; Vasilyev 1990: 205; *for 1800–1897:* Panzac's (1987) estimates.

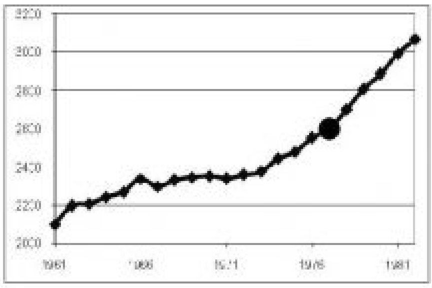


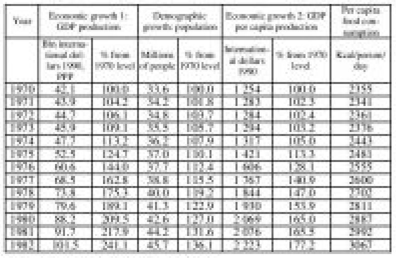
**Fig. 12.** Per capita food consumption in Egypt, 1961–1982, kcal/day

*Source:* FAO 2014.

The riots took place in all the large Egyptian cities, several hundred thousand people participated in them, not less than 800 fell victim (see, *e.g.*, Hirst 1977). Seemingly, we should deal here with nothing else than Malthusian scenario, as the protesters clearly complained about food insufficiency, while in the 1960s – 1970s the Egyptian population was growing exceedingly fast (see Fig. 11).

In this regard it seems reasonable to view the actual dynamics of per capita food consumption in Egypt in the 1960s and 1970s (see Fig. 12).

**Table 2.** Egyptian economic-demographic dynamics in the 'Sadat epoch' (1970–1982)



| Year | Economic growth 1: GDP production | | Demographic growth population | | Economic growth 2: GDP per capita production | | Per capita food consumption |
|---|---|---|---|---|---|---|---|
| | Bln international dollars 1990, PPP | % from 1970 level | Millions of people | % from 1970 level | International dollars 1990 | % from 1970 level | Kcal/person/day |
| 1970 | 42.1 | 100.0 | 33.6 | 100.0 | 1 254 | 100.0 | 2155 |
| 1971 | 43.9 | 104.2 | 34.2 | 101.8 | 1 283 | 102.3 | 2341 |
| 1972 | 44.7 | 106.1 | 34.8 | 103.7 | 1 284 | 102.4 | 2361 |
| 1973 | 45.9 | 109.1 | 35.5 | 105.7 | 1 294 | 103.2 | 2376 |
| 1974 | 47.7 | 113.2 | 36.2 | 107.9 | 1 317 | 105.0 | 2443 |
| 1975 | 52.5 | 124.7 | 37.0 | 110.1 | 1 421 | 113.3 | 2481 |
| 1976 | 60.6 | 144.0 | 37.7 | 112.4 | 1 606 | 128.1 | 2555 |
| 1977 | 68.5 | 162.8 | 38.8 | 115.5 | 1 767 | 140.9 | 2600 |
| 1978 | 73.8 | 175.3 | 40.0 | 119.2 | 1 844 | 147.0 | 2702 |
| 1979 | 79.6 | 189.1 | 41.3 | 122.9 | 1 930 | 153.9 | 2811 |
| 1980 | 88.2 | 209.5 | 42.6 | 127.0 | 2 069 | 165.0 | 2887 |
| 1981 | 91.7 | 217.9 | 44.2 | 131.6 | 2 076 | 165.5 | 2992 |
| 1982 | 101.5 | 241.1 | 45.7 | 136.1 | 2 223 | 177.2 | 3067 |

*Data source:* Maddison 2001, 2010; FAO 2014.

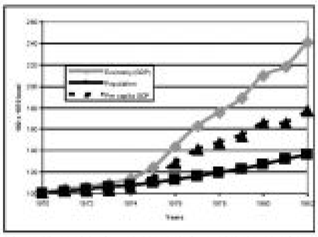


**Fig. 13.** Egyptian economic-demographic dynamics in the 'Sadat epoch' (1970–1982)

Evidently, Malthusian scenario does not work here. Indeed, in the early 1960s the problem of undernourishment was still quite acute for Egypt, and per capita consumption was lower than the WHO recommended norm of 2300–2400 kcal/person/day (Naiken 2002). In the mid-1960s Egypt reached this level, but could not exceed it before 1974. After 1973 per capita food consumption increased rapidly, getting over 3000 kcal/day in 1982 (next year after Sadat's death) and never after decreasing beyond this level. Thus, the problem of overeating became more relevant for Egypt than the one of undernourishment. This success should be attributed to the *Infitah* economic reforms launched by Sadat administration in 1974 (see, *e.g.*, Weinbaum 1985: 215–216). Indeed, though population grew by 36.1 % from 1970 to 1982, Egyptian GDP grew by 141.1 % during the same period, the major part of this growth taking place during *Infitah*. As a result, GDP per capita grew almost twofold, which correlated with the similarly rapid growth in per capita consumption (see Table 2 and Fig. 13).

Thus, ‘bread riots’ occurred in Egypt at that very time when the country was successfully escaping from the Malthusian trap.

### *Syria – The 1982 Hama Rebellion*

In Syria after the end of the Second World War the largest popular rebellion took place in 1982 in Hama. The rebellion was suppressed with regular army units, aviation, artillery, and tanks. According to some estimates, the number of dead reached 40 thousand, including 1000 soldiers of regular army (see, *e.g.*, Fisk 1990; Friedman 1998; Wiedl 2006).

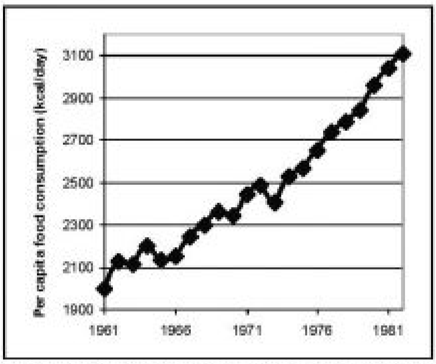


**Fig. 14.** Per capita food consumption in Syria, 1961–1982, kcal/day

*Source*: FAO 2014.

After the cases considered above the picture of dynamics of per capita food consumption in Syria in the two decades preceding the Hama rebellion should not look surprising. Yet, with respect to this country the ‘counter-Malthusian’ dynamics looks especially impressive – indeed, in the nine years preceding the rebellion the per capita food consumption in Syria was growing continuously and very rapidly (see Fig. 14).

In general, as we see, in the two decades preceding the largest popular rebellion in its post-war history Syria had escaped the Malthusian trap in a rather successful way, having moved within a historically very short period quite far from the level of explicit undernourishment of the early 1960s and reaching by 1982 a level that could be more accurately characterized as overeating.

### *Civil War in El Salvador*

In 1980 a civil war began in El Salvador; it continued till 1992 and led to the death of 75 thousand inhabitants of this country – a colossal number for a country with total population of about 4.5 mln people at the moment of the civil war start (see, *e.g.*, Montgomery 1995).

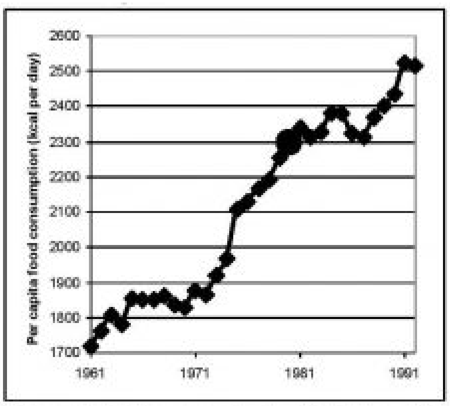


**Fig. 15.** Per capita food consumption in El Salvador, 1961-1992, kcal/day
*Source*: FAO 2014.

In the meantime, the per capita food consumption dynamics in El Salvador looked as follows (see Fig. 15):

We obviously see here a picture that is generally similar to the cases observed above; however, it has some noticeable nuances. As we see, still in the early 1960s the majority of the Salvadorian population confronted the most serious (in comparison with all the other cases considered above) undernourishment problems. The situation with food consumption somehow improved in this country in the 1960s. However, it improved in the most significant way just in the decade that preceded directly the outbreak of the Salvadorian civil war. It was just the year of the civil war start when per capita food consumption in this country reached the level recommended by the World Health Organization.

*Civil War in Liberia*

In 1989 a civil war started in Liberia which continued up to 2003. About 200,000 – 300,000 Liberians were killed (of the total population slightly more than 2 mln at the war start) (Frenkel 1999; Huband 1998; Williams 2006). General dynamics of per capita food consumption in Liberia during 3 decades preceding the civil war looked as follows (see Fig. 16):

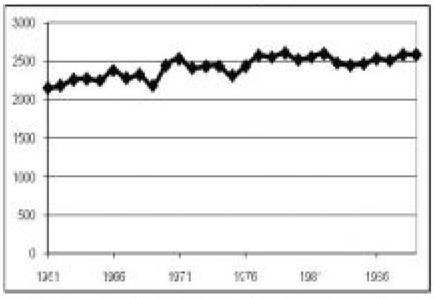


**Fig. 16.** Per capita food consumption, Liberia, 1961-1989, kcal/day
*Source*: FAO 2014.

Thus, in the 1960s – 1980s (before civil war) per capita food consumption tended to grow in Liberia. While in the early 1960s there was some undernourishment, in the 1980s per capita consumption was thoroughly higher than the recommended norm of 2300–2400 kcal/day. Besides, in the year of civil war start *Liberia occupied the FIRST place in Tropical Africa according to the level of per capita food consumption* (see Fig. 17).

Liberian case is among the most tragic ones, as not only did the country ‘stumble’ at the escape from the Malthusian trap, but also fell back into the trap again (see Fig. 18).

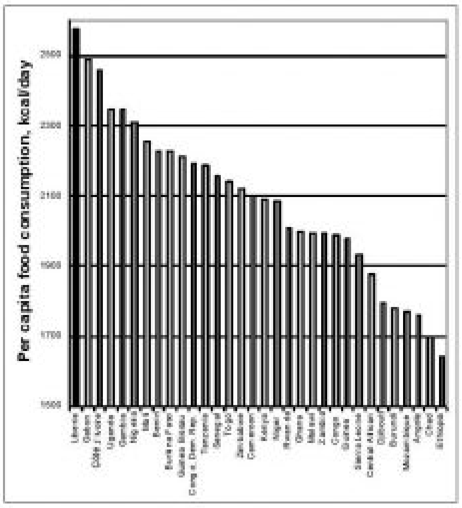


**Fig. 17.** Average per capita food consumption (kcal/day) in various countries of Tropical Africa in 1989 (*i.e.*, in the year of the Liberian civil war start)

*Source*: FAO 2014.

**Fig. 18.** Per capita food consumption in Liberia, 1984–2005, kcal/day

*Source*: FAO 2014.

Thus, in 2005 per capita food consumption had not yet approached the pre-war level and was significantly lower than even the early 1960s level. After civil war started, an unfavorable mechanism of positive feedback formed in Liberia, as civil war destroyed economy, which reduced the per capita consumption, which increased the unrest and worsened the civil war. During the short breaks the renewed (even before economy restoration) rapid demographic growth did not allow for any remarkable improvement in living standards (nor in per capita consumption) or even led to its worsening, which resulted in new unrests and new stages of civil war. Currently Liberia is again trying to escape from the Malthusian trap, but there is no warranty against its getting into ‘a trap at the escape from the Malthusian trap’ once more.

### *Civil War in Côte d’Ivoire*

One of the most recent civil wars in Africa occurred in Côte d’Ivoire in 2002 (Akokpari 2007). Per capita food consumption dynamics thereby looked as follows (see Fig. 19):

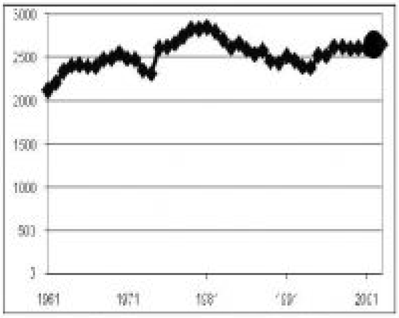


**Fig. 19.** Per capita food consumption, Côte d'Ivoire, 1961–2003, kcal/day
*Source*: FAO 2014.

Thus, undernourishment problem was solved in the 1960s, and at the civil war start per capita food consumption was stably higher than the WHO recommended norm. Besides, in the civil war start year Côte d’Ivoire rated among the top Tropical African countries according to per capita food consumption indicator (see Fig. 20).

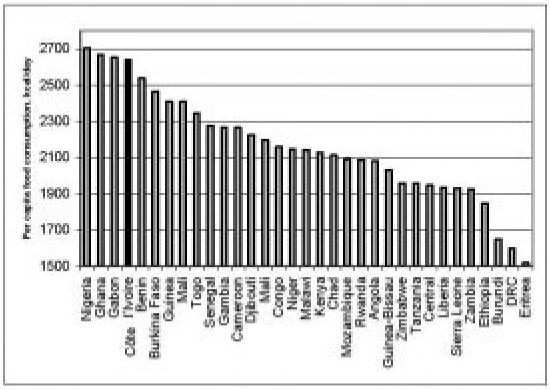


**Fig. 20.** Average per capita food consumption (kcal/day) in various countries of Tropical Africa in 2002 (*i.e.*, in the year of the civil war start in Côte d'Ivoire)
*Source*: FAO 2014.

### *Islamic Revolution in Iran*

Against the background of the material considered above the dynamics of per capita food consumption in Iran in the years preceding the successful Islamic Revolution of 1979 in Iran should not look really surprising (see Fig. 21).

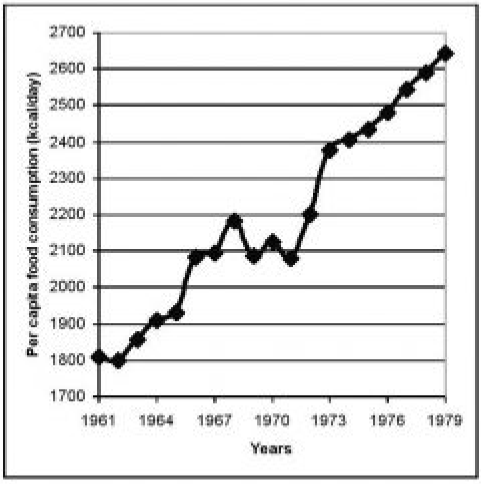


**Fig. 21.** Per capita food consumption in Iran, 1961–1979, kcal/day
*Source*: FAO 2014.

This diagram suggests that the system of socioeconomic reforms (the so-called

‘White Revolution’ [see, *e.g.*, Abrahamian 2008: 123–154]) started by the last Iranian Shah Mohammad Reza Pahlavi in 1963 brought conspicuous positive results. Indeed, the Iranian population grew very rapidly in the years preceding the Iranian Revolution. For example, between 1965 and 1979 it grew from 25 to almost 38 million (see, *e.g.*, Maddison 2001, 2010), that is by about 50 %. However, in the same period of time the agricultural output in Iran grew by more than 100 % (see Fig. 22).

In the meantime Iranian GDP in this period grew by more than 150 %, as a result of which per capita GDP increased by 75 % (Maddison 2001; 2010). Hence, the salient positive trend of per capita food consumption dynamics in Iran reflects up to a rather high degree the real economic successes that were achieved by this country as Mohammad Reza Pahlavi’s administration was implementing the system of socioeconomic reforms known as the ‘White Revolution’.

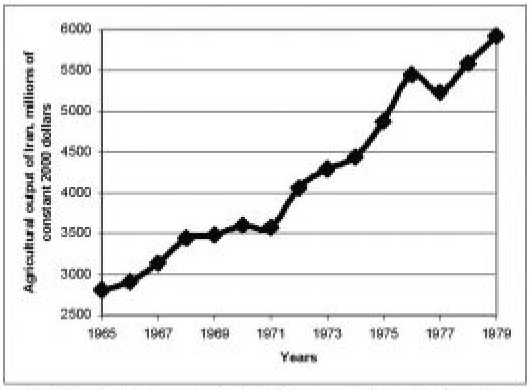


**Fig. 22.** Dynamics of agricultural output in Iran, 1965–1979 (in millions of constant 2000 dollars)

*Source*: World Bank 2014.

*Civil War in Algeria*

Let us consider in some greater detail the structural-demographic dynamics of Algeria 1962–1991, that is in the period after independence and before the start of the civil war (1992–2002) which can be characterized as a failed Islamic revolution (Kepel 2004: 164–180, 247–266). Per capita consumption dynamics in Algeria during the two decades preceding the civil war looked as follows (see Fig. 23):

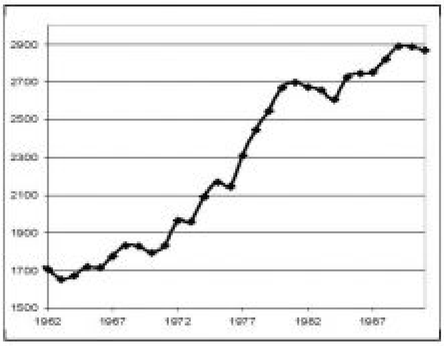


**Fig. 23.** Per capita food consumption, Algeria, 1962–1991, kcal/day

*Sources*: FAO 2014; Zinkina 2010: 260.

Obviously, the dynamics observed is just contrary to the one that could be expected on the basis of the Malthusian trap assumption. Indeed, in the first years after independence the Algerian population was far below the WHO norm and greatly undernourished. Only in 1973 did it manage to go over the critical level of 1850 kcal/day. However, there was no unrest in this period. By the late 1970s Algeria exceeded the WHO 2300–2400 kcal/day recommended level and did not fall below this level any more. By the late 1980s it was more than 2800 kcal/day. This dynamics correlates very well with the rapid growth of agricultural labor productivity proving the significant success achieved by Algeria in the modernization of agriculture (see Fig. 24).

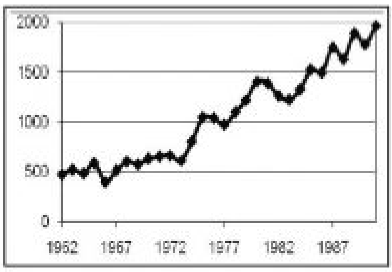


**Fig. 24.** Labor productivity in Algerian agriculture, 1962–1991 (constant 2000 dollars per agricultural worker)

*Source:* World Bank 2014.

*A Trap at the Escape from the Malthusian Trap:*
*Empirical Data*

During the three decades preceding the start of the civil war Algeria successfully came out of the Malthusian trap; in fact, as we shall see below, this very escape to a large extent generated the forces that played a crucial role in the genesis of the Algerian civil war.

By definition, the escape from the Malthusian trap implies the solution of the famine problem, which in its turn implies a significant decrease in the death rates. Indeed, for countries with per capita consumption up to 2900 kcal/day there is a strong negative correlation observed between this indicator and the crude death rate (see Fig. 25 and Table 3).

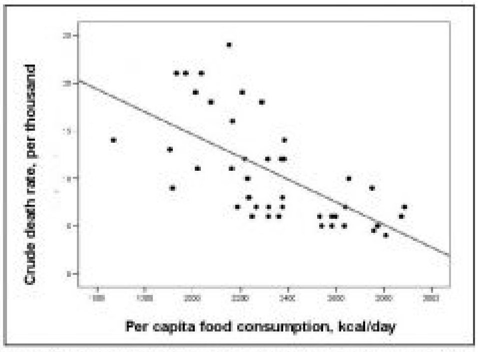


**Fig. 25.** Correlation between per capita food consumption and crude death rate (according to 1995 data for countries with consumption up to 2900 kcal/day)

*Note:* $r = -0.64$, $R^2 = 0.41$, $p << 0.0001$. Source: SPSS 2010.

**Table 3.** Regression analysis

| | Non-standardized coefficient | | Standardized coefficient | $t$ | Statistical significance ($p$) |
|---|---|---|---|---|---|
| Model | $B$ | Stat. error | $\beta$ | | |
| (Constant) | 38 | 5.1 | | 7.45 | << 0.0001 |
| Per capita food consumption, kcal/day | –0.012 | 0.002 | –0.639 | –5.45 | << 0.0001 |
| *Dependent variable:* Crude death rate (per 1000) | | | | | |

As escape from the Malthusian trap usually occurs at the first stage of demographic transition, the results of regression analysis imply that this escape

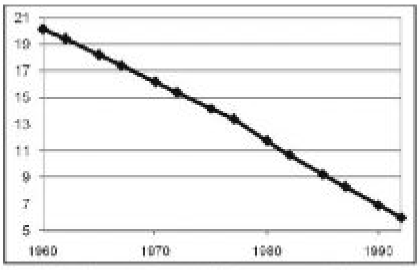


**Fig. 26.** Crude death rate (per 1000) dynamics in Algeria, 1960–1992

*Source:* World Bank 2014.

(usually accompanied by more than 1000 kcal/day growth in per capita consumption) must be accompanied by population growth rates increase by not less than one per cent, which implies a very significant acceleration. This can be seen in Algeria. The escape from the Malthusian trap was accompanied by a dramatic fall in death rate (see Fig. 26).

Thus, in three decades preceding the start of the civil war the Algerian death rates declined threefold! During the most of this period birth rate was stably high,

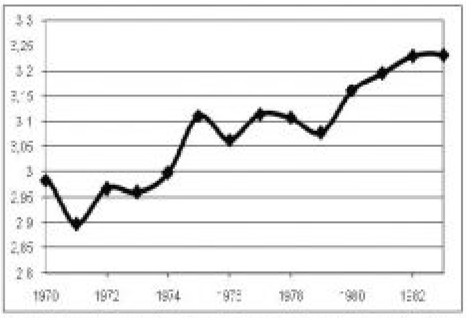
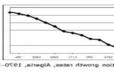


**Fig. 27.** Relative population growth rates, Algeria, 1970–1983, % a year

*Source:* Maddison 2001, 2010.



so population growth rates were increasing and st to decline only in the mid-1980s, but in 1991 (civil war start) they were still very high (2.4 % or 600,000 a year) (see Figs 27 and 28).

Naturally, such an impetuous population growth would almost inevitably create serious structural strains in any social system. However, within the Algerian social system this was not the only generator of structural strains.

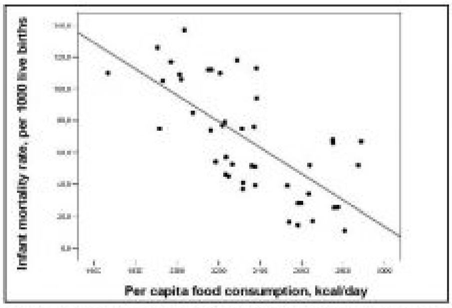


**Fig. 29.** Correlation between per capita food consumption and infant mortality rate (per 1000 live births) according to 1995 data, for countries with less than 2900 kcal/day

*Note:* $r = -0.69$, $R^2 = 0.475$, $p << 0.0001$ (for interval < 2700 kcal the value of $r$ achieves $-0.74$).

*Source:* SPSS 2010.

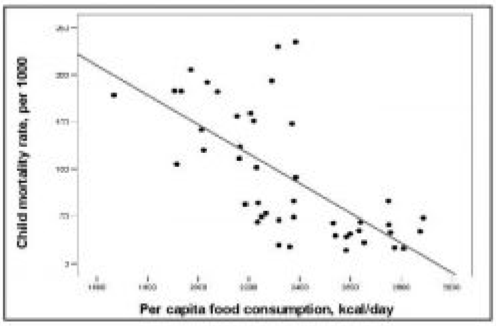


**Fig. 30.** Correlation between per capita food consumption and (under-five) child mortality rate (per 1000) according to 1995, data for countries with less than 2900 kcal/day)

*Note:* $r = -0.68$, $R^2 = 0.46$, $p << 0.0001$ (for interval < 3000 kcal value of $r$ achieves $-0.7$).

*Source:* SPSS 2010.

Within socioeconomic systems escaping from the Malthusian trap per capita consumption growth correlates in an especially strong way with the decrease of infant and child mortality (see Figs 29 and 30):

Predictably, Algerian escape from the Malthusian trap was also accompanied by a precipitous fall of infant and child mortality rates (Figs 31 and 32):

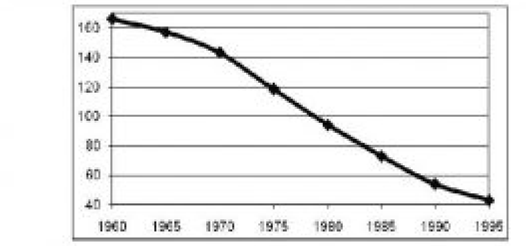


**Fig. 31.** Infant mortality, Algeria, 1960–1995, per 1000 live births

*Source*: World Bank 2014.

Thus, while crude death rate in Algeria in 1960–1995 decreased threefold, infant mortality declined almost fourfold during the same period, while child (under-five) mortality fell almost fivefold!

Thus, at the first phase of demographic transition (that tends to coincide with the escape from the Malthusian trap) death rate declines dramatically (Vishnevski 1976, 2005; Chesnais 1992; Korotayev, Malkov, and Khaltourina 2006a), the greatest decline occurring in infant and under-five mortality, while birth rates still remain high. Thus, out of six-seven children born by a woman, five-six children survive up to reproductive age, not two or three as earlier. This leads not only to the demographic explosion, but also to the formation of the 'youth bulge', as the generation of children turns out to be much larger in number than their parents' generation. Thus, in Algeria the share of youth cohort in the total population greatly increased at the escape from the Malthusian trap (see Fig. 33).

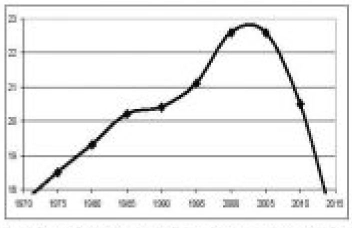


**Fig. 33.** Youth cohort (aged 15–24) in the population of Algeria, 1970–2005, with a forecast up to 2015, %

*Source*: UN Population Division 2010.

A number of researchers, first of all Goldstone (1991, 2002), regard the rapid growth of the youth share in population as a major factor of political instability.

For example, Goldstone maintains that 'the rapid growth of youth can undermine existing political coalitions, creating instability. Large youth cohorts are often drawn to new ideas and heterodox religions, challenging older forms of authority. In addition, because most young people have fewer responsibilities for families and careers, they are relatively easily mobilized for social or political conflicts. Youth have played a prominent role in political violence throughout recorded history, and the existence of a ‘youth bulge’ (an unusually high proportion of youths aged 15–24 years relative to the total adult population) has historically been associated with times of political crisis. Most major revolutions … [including] most twentieth-century revolutions in developing countries – have occurred where exceptionally large youth bulges were present’ (Goldstone 2002: 10–11; see also Goldstone 1991; Moller 1968; Mesquida and Weiner 1999; Heinsohn 2003; Fuller 2004).

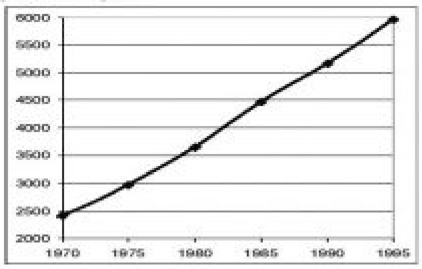


**Fig. 34.** Dynamics of young (aged 15–24) Algerian population, thousands, 1970–1995

*Source:* UN Population Division 2010.

Let us consider the ‘youth bulge’ factor in Algeria in more detail. This will allow specifying some other channels of this factor’s impact upon the political instability genesis. First of all consider the dynamics of absolute number of young Algerians (see Fig. 34).

Thus, number of Algerian youths was growing explosively at the eve of the civil war, more than doubling within 20 years (1970–1990). In 1980–1995 it grew by 65 %. Accordingly, in order to prevent catastrophic unemployment, new workplaces had to be created at a proportionate rate, which is difficult even for a fast-growing economy. If an economy is not growing as fast, unemployment rockets up (in Algeria it reached 40 % in the late 1980s: Haldane 1989; Zinkina 2010: 261), especially among the youth (*i.e.*, among that very age cohort which is most inclined to aggression). Against such a background it usually becomes more and more difficult to prevent major political upheavals.

There is one more force generated by modernization in general (and the escape from the Malthusian trap, in particular) that can contribute to the genesis of political instability, namely urbanization (see, *e.g.*, Grinin and Korotayev 2009; Grinin 2010). Indeed, the start of escape from the Malthusian trap leads to a stable decline in death rates, stipulating the first phase of demographic transition. The escape itself is achieved through agricultural labor productivity growth (as was mentioned above, in Algeria it grew fivefold during the two decades preceding the civil war).

In general, the escape from the Malthusian trap stimulates urban population growth in several ways. Death rate decline in conjunction with still high birth rates leads to a rapid increase of population growth rates, so excessive rural population appears. This population is pressed out of the rural areas, as labor productivity grows, and less workforce is required for agricultural work. This population may well be supplied with food resources as per capita food production and consumption increases at the escape from the Malthusian trap, so such escape strongly supports the rapid intensification of urbanization processes, allowing for the urbanization levels which could not be achieved in agrarian societies.

Let us consider this with respect to the Algerian case (see Fig. 35).

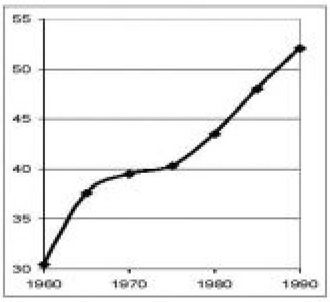


**Fig. 35.** Dynamics of urban population percentage in Algerian, 1970–1990

*Source*: UN Population Division 2010.

Thus, less than one-third of Algerians resided in cities at the eve of independence. At the eve of the civil war the urban population constituted more than a half of the whole population. This increase took place against the background of a very fast demographic growth. Thus, urban population was growing particularly fast in absolute numbers (see Fig. 36).

Thus, during 30 years preceding the civil war start in Algeria the urban population grew fourfold, which evidently could serve as a major destabilizing factor.

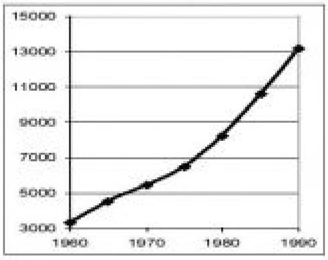


**Fig. 36.** Total urban population of Algeria, 1970–1990, thousands

*Source*: UN Population Division 2010.

The escape from the Malthusian trap engenders a rapid growth of urban population due to both natural increase and rural-urban migrations. This causes social tensions, as jobs and accommodation need to be supplied for the fast-growing mass of people. Besides, rural migrants usually have no skills appropriate for urban settings and can only find unqualified and low-paid jobs, which causes growing discontent among them.

The situation is exacerbated by the fact that most of the rural-urban migrants are usually young. The ‘youth bulge’ and intensive urbanization factors act together, making the number of young urban population rocket up.[6] For example, during 30 years of independence in Algeria its young population grew almost threefold, while its urban population increased fourfold, so the number of the urban youth increased by an order of magnitude (which was just a logical consequence of the country’s escape from the Malthusian trap). Thus, not only did the most radically inclined part of population rocket up in numbers, but it also got concentrated in cities (that, we should not forget, are centers of political system), which is a serious danger for political stability, especially if economic decline occurs.

It appears quite useful to consider the action of the above-described factors at the ‘grassroots’ level. For this we find it appropriate to reproduce Kepel’s description of the events in Algeria that preceded the October riots of 1988, which served as an omen of the forthcoming civil war:
*…A population explosion had thrust the children of the fellahs (farmers) into the cities and their outskirts, where conditions were precarious… In 1989, 40 percent of Algeria’s population of 24 million were under 15 years of age; the urban population was in excess of 50 percent of the total population… The official unemployment rate was 18.1 percent of the working population, though in reality joblessness was much higher; in 1995 it rose – again officially – to 28 percent. The young urban poor of Algeria were mocked as hittistes – from the Arab word hit, ‘wall’. This jibe derived from the image of jobless young men with nothing to do all day but lean against a wall. The joke was that, in a socialist country where in theory everyone was supposed to have a job, the profession of a hittiste consisted in propping up walls that would otherwise collapse. The hittistes were assumed to be passive – unlike the Iranian ones, who were glorified by religious movements and hailed as the messengers of history and the Revelation.*

*At the time of the October 1988 riots, oil and gas represented 95 percent of the nation’s exports and supplied more than 60 percent of the government’s yearly budget… The Algerian state was a kind of popular democracy cum oil. The state used its oil revenues to buy social pacification… This balance of power, maintained by subsidies, socialism, repression, and official ideology, was ultimately dependent on the fragile economic equilibrium created by the high price of oil. In 1986, when oil prices collapsed, half of Algeria’s budget was wiped out and the whole structure fell down in ruins. Worse, the population explosion*

> *had created a demand for… urban infrastructure, housing, and employment that continued to increase… The construction industry in particular had failed spectacularly to keep pace with the housing demand; the result was the kind of slums and overcrowded urban conditions that invariably lead to social eruption.*
>
> *It was in this deteriorating climate, punctuated by continual strikes, that riots broke out on October 4, 1988. Mobs of impoverished Algerian youths attacked such symbols of the state as buses, road signs, and Air Algeria agencies, along with any automobile that looked expensive… These days… marked the emergence of the young urban poor as a force to be reckoned with. The once ridiculed hittistes had shown that they could seize and hold power in the streets, shaking to its foundations a regime that had excluded them and whose legitimacy they scorned (Kepel 2006: 159–161).*

### *A Trap at the Escape from the Malthusian Trap:*
### *Logical and Mathematical Models*

Thus, the emergence of major sociopolitical upheavals at the escape from the Malthusian trap is not an abnormal, but a regular phenomenon. So, a special explanation is rather needed for exceptions, when social systems managed to avoid such shocks.

Why should such upheavals be treated as a regular phenomenon? The answer may be summarized as follows:

1) Start of the escape from the Malthusian trap tends to bring about a precipitous death rate decline and, consequently, an explosive acceleration of the population growth rates (which in itself can lead to a certain increase in sociopolitical tensions).

2) The start of the escape is accompanied by especially strong decreases in infant and under-five mortality, which raises the proportion of the youth in the overall population (and especially in the adult population) – the so-called ‘youth bulge’.

3) This increases sharply the proportion of the part of population most inclined to radicalism.

4) The impetuous growth of the young population requires the creation of enormous numbers of new jobs, which is a serious economic problem, while the youth unemployment growth can have a particularly strong destabilizing effect, creating an ‘army’ of potential participants for various political upheavals, including civil wars, revolutions, and state breakdowns.

5) Escape from the Malthusian trap stimulates a vigorous growth of the urban

population. Besides, excessive population is pressed out from the countryside by the growth of agricultural labor productivity. Massive rural-urban migration almost inevitably creates a significant number of those dissatisfied with their current position, as initially the rural-urban migrants mostly can only get unskilled low-paid jobs and low-quality accommodation.

6) Escape from the Malthusian trap is achieved through the development of new economic sectors and decline of the old ones. Such structural changes cannot proceed painlessly, as old qualification of workers loses its value and, not having necessary new skills, these workers are obliged to take up low-qualified jobs, which makes them socially discontent.

7) The young people make up the majority of rural-urban migrants, so the ‘youth bulge’ and intensive urbanization factors act together, producing a particularly strong destabilizing effect. Not only does the most radically inclined part of population rocket up in numbers, but it also gets concentrated in major cities / political centers.

8) This can result in serious political destabilization even against the background of a rather stable economic growth (see Fig. 37). The probability of political destabilization naturally increases dramatically if an economic crisis occurs, or if the government loses its legitimacy due to any other causes (such as military defeats), though the recent ‘Arab Spring’ events have demonstrated once again in a rather salient way that even this is not really necessary (see, *e.g.*, Korotayev and Zinkina 2011).

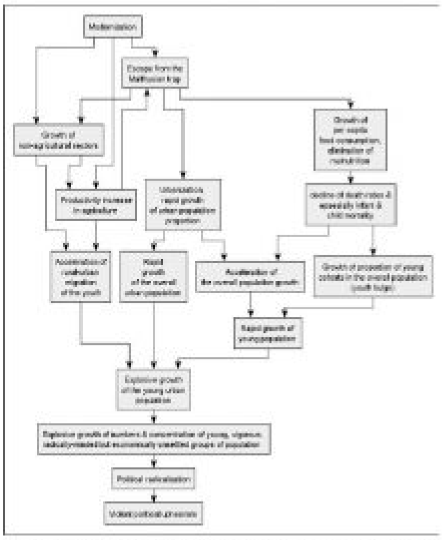
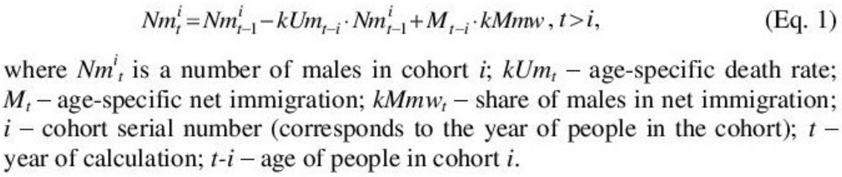


**Fig. 37.** ‘A trap at the escape from the Malthusian trap’. A cognitive model

As regards mathematical models describing the formation of the ‘youth bulge’ (that, in combination with some other factors, can lead to major sociopolitical upheavals even against the background of an apparently rather successful escape from the Malthusian trap), they are rather well-developed and are widely used in demographic research.

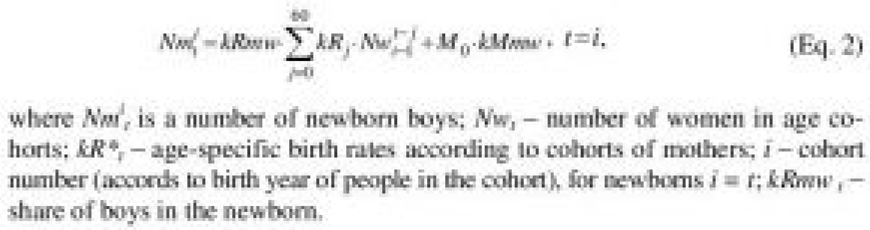
We can regard a model by Ototsky (2008) as an example. It uses component method (or cohort analysis) to describe mathematically the dynamics of society age structure. The method of components implies dividing the whole population into groups of people of one age, so-called ‘year cohorts’, which are divided into male and female ones for correct estimation of the population reproductive potential. For each cohort their own birth, death, and migration rates are determined. Birth year of people subsumed under the cohort is regarded as a serial number of this cohort. Number of males (or females) in a cohort is expressed in the following way:



$$Nm_t^i = Nm_{t-1}^i - kUm_{t-i} \cdot Nm_{t-1}^i + M_{t-i} \cdot kMmw, \; t > i, \qquad \text{(Eq. 1)}$$

where $Nm^i_t$ is a number of males in cohort $i$; $kUm_t$ – age-specific death rate; $M_t$ – age-specific net immigration; $kMmw_t$ – share of males in net immigration; $i$ – cohort serial number (corresponds to the year of people in the cohort); $t$ – year of calculation; $t\text{-}i$ – age of people in cohort $i$.

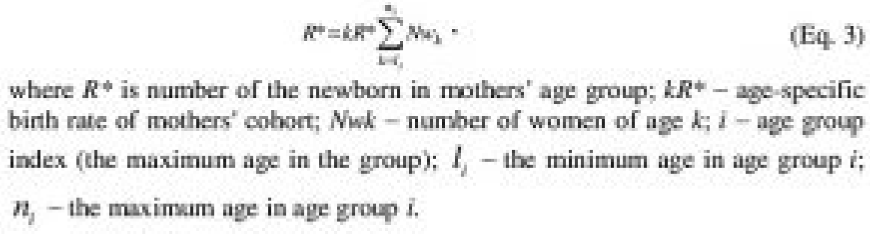
Number of newborn boys (and girls) is calculated with the following equation:



$$Nm_t^i = kRmw \cdot \sum_{j=0}^{60} kR_j \cdot Nw_{t-j}^{t-j} + M_0 \cdot kMmw, \; t = i, \qquad \text{(Eq. 2)}$$

where $Nm^i_t$ is a number of newborn boys; $Nw_t$ – number of women in age cohorts; $kR^*_t$ – age-specific birth rates according to cohorts of mothers; $i$ – cohort number (accords to birth year of people in the cohort), for newborns $i = t$; $kRmw_t$ – share of boys in the newborn.

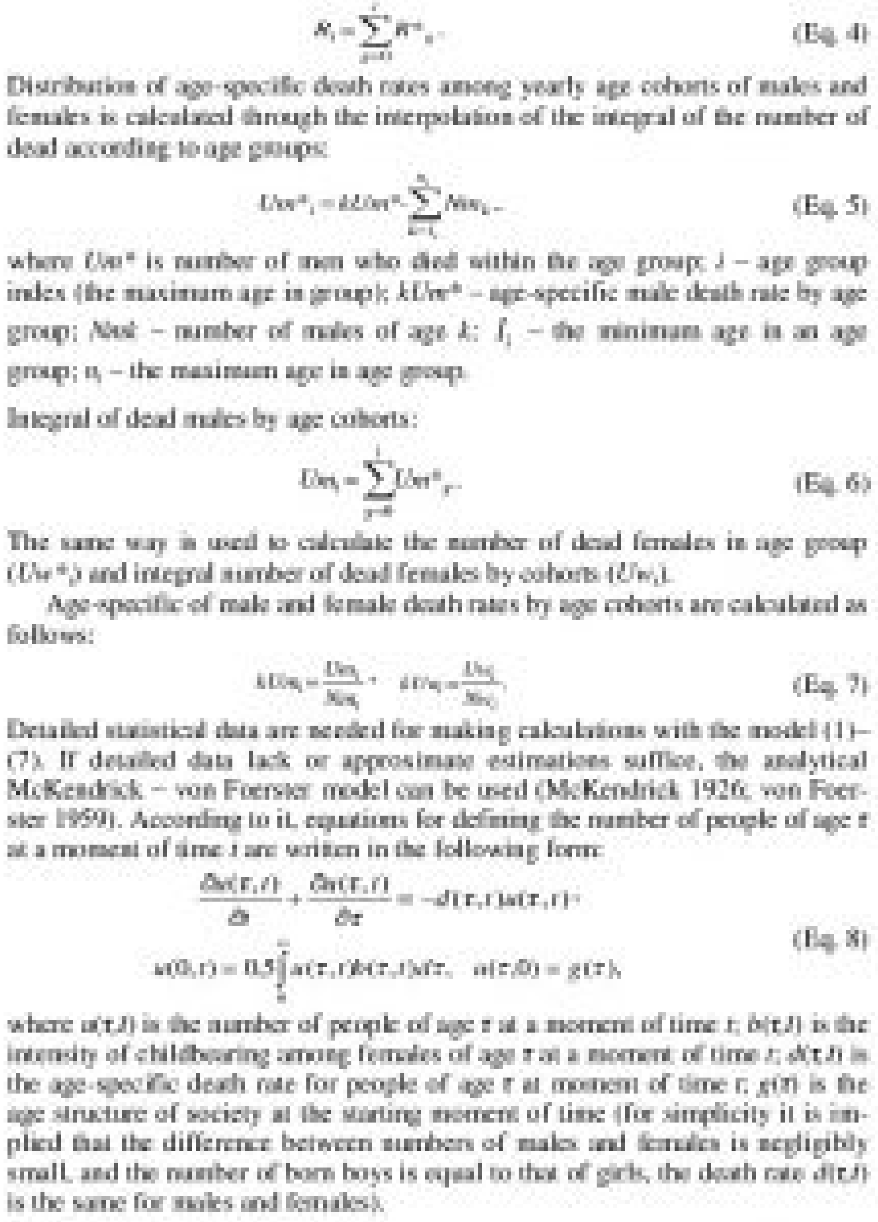
Number of the newborn in an age group is calculated in the following way:



$$R^* = kR^* \sum_{k=l_i}^{n_i} Nw_k \qquad \text{(Eq. 3)}$$

where $R^*$ is number of the newborn in mothers’ age group; $kR^*$ – age-specific birth rate of mothers’ cohort; $Nwk$ – number of women of age $k$; $i$ – age group index (the maximum age in the group); $l_i$ – the minimum age in age group $i$; $n_i$ – the maximum age in age group $i$.

General number of the newborn by mother cohorts is calculated with the following equation:



$$R_i = \sum_{j=0}^{i} R^*_{j}, \qquad \text{(Eq. 4)}$$

Distribution of age-specific death rates among yearly age cohorts of males and females is calculated through the interpolation of the integral of the number of dead according to age groups:

$$Um^*_i = kUm^* \cdot \sum_{k=l_i}^{n_i} Nm_k, \qquad \text{(Eq. 5)}$$

where $Um^*$ is number of men who died within the age group; $i$ – age group index (the maximum age in group); $kUm^*$ – age-specific male death rate by age group; $Nmk$ – number of males of age $k$; $l_i$ – the minimum age in an age group; $n_i$ – the maximum age in age group.

Integral of dead males by age cohorts:

$$Um_i = \sum_{j=0}^{i} Um^*_j, \qquad \text{(Eq. 6)}$$

The same way is used to calculate the number of dead females in age group ($Uw^*_i$) and integral number of dead females by cohorts ($Uw_i$).

Age-specific of male and female death rates by age cohorts are calculated as follows:

$$kUm_i = \frac{Um_i}{Nm_i}, \quad kUw_i = \frac{Uw_i}{Nw_i}. \qquad \text{(Eq. 7)}$$

Detailed statistical data are needed for making calculations with the model (1)–(7). If detailed data lack or approximate estimations suffice, the analytical McKendrick – von Foerster model can be used (McKendrick 1926, von Foerster 1959). According to it, equations for defining the number of people of age $\tau$ at a moment of time $t$ are written in the following form:

$$\frac{\partial u(\tau,t)}{\partial t} + \frac{\partial u(\tau,t)}{\partial \tau} = -d(\tau,t)u(\tau,t),$$
$$u(0,t) = 0.5\int_0^\infty u(\tau,t)b(\tau,t)d\tau, \quad u(\tau,0) = g(\tau), \qquad \text{(Eq. 8)}$$

where $u(\tau,t)$ is the number of people of age $\tau$ at a moment of time $t$; $b(\tau,t)$ is the intensity of childbearing among females of age $\tau$ at a moment of time $t$; $d(\tau,t)$ is the age-specific death rate for people of age $\tau$ at moment of time $t$; $g(\tau)$ is the age structure of society at the starting moment of time (for simplicity it is implied that the difference between numbers of males and females is negligibly small, and the number of born boys is equal to that of girls, the death rate $d(\tau,t)$ is the same for males and females).

Model (8) is capable of describing the emergence of ‘youth bulge’ in a society escaping from the Malthusian trap. Assume that up to some moment of time t0 the society was demographically stable (its age structure did not change, see Fig. 38), while fertility rate was high (7 children per woman) and infant mortality was high, too.

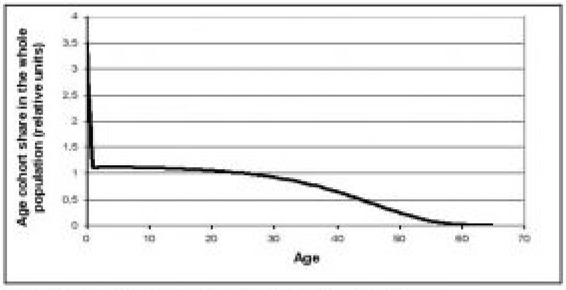


**Fig. 38.** Initial age structure of the society (simulation)

If at moment t*0* infant mortality starts declining and decreases fivefold in 30 years, then according to Eq. 8 society age structure will substantially change with the unchanged structure of birth rate (see Fig. 39, lines correspond to successive change of

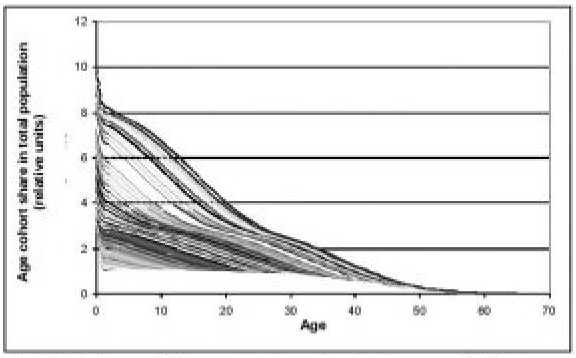


**Fig. 39.** Change of the age structure with the decrease of infant mortality (simulation)

Obviously, infant mortality decline leads to an increase in proportion of the youth within total population. Thereby a 'youth bulge' emerges (see Fig. 40 reflecting the change of percentage of population aged 15–24 in the overall population starting from $t_0 + 20$ years).

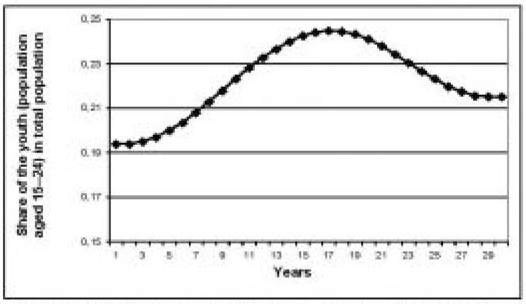


**Fig. 40.** Change of the youth (population aged 15–24) proportion in the total population with infant mortality decline (simulation)

Obviously, despite their simulation character the results of calculations correlate with the empirical data rather well (see Fig. 33 above).

Fig. 40. Change of the youth (population aged 15–24) proportion in the total population with infant mortality decline (simulation)

The excessive young population not required in the rural areas moves to cities searching for better life, which affects the development of socioeconomic and political processes in the society. The result of these processes depends on particular conditions. In any case, it is a critical period in the life of any society escaping from the Malthusian trap.

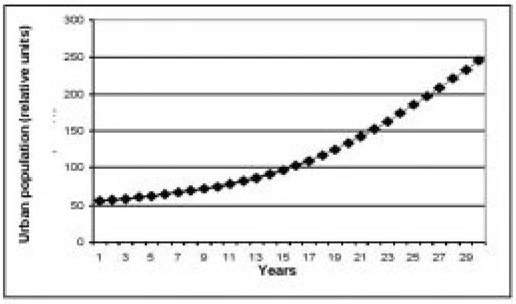


**Fig. 41.** Urban population growth under the impact of migration inflow from rural areas (simulation)

Figs 41 and 42 represent the results of calculations on urban population growth and urban population percentage increase with an assumption that the increasing demographic pressure in rural areas presses the excessive population (and especially the young population) to move to the urban areas with probability about

0.5 (calculations are presented for the same conditions as in Figs 38–40 starting from $t_0$ + 20 years).

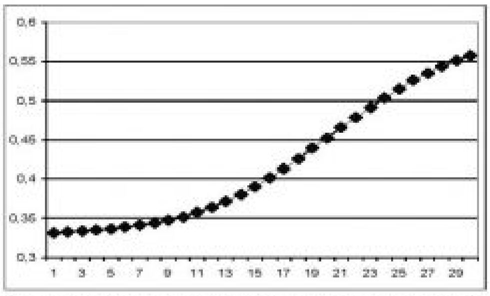


**Fig. 42.** Increase in proportion of urban population under the impact of intensifying rural-urban migration (simulation)

Naturally, mass rural-urban migration is possible only in conditions of general economic growth when some 'surplus' product appears which allows to feed the growing urban population. In order to account for this condition we can use the general dynamic urbanization equation developed in our earlier works (see, *e.g.*, Korotayev 2006):

$$\frac{du}{dt} = aSu(u_{\lim} - u), \qquad \text{(Eq. 8)}$$

where $u$ is the proportion of urban population ('urbanization index'); $S$ is per capita 'surplus'; $a$ is a constant; $u_{\lim}$ is the maximum possible urban population proportion (which can be estimated as lying between 0.8–0.9 and in this context may be viewed as the 'saturation level'; in calculations presented below this value was taken as 0.9).

The sense of this equation is as follows: urbanization being low, the probability of a rural resident migrating to town is the higher, the greater urban population proportion. Indeed, the higher this proportion, the greater the probability of having some relative or acquaintance in town, who will be able to supply the rural migrant with the necessary information and initial support (an ordinary peasant will hardly decide to move 'into nowhere'). However, urban population growth rates slow down when approaching the saturation level.

Besides, both in our equation and in real life urbanization rates depend also on the level of economic development, which in our equation is calculated through the per capita surplus. Indeed, if rural areas do not produce surplus, urbanization becomes impossible, while in order for it to start (and accelerate) significant economic growth is required. It also requires the labor productivity growth, for example, in agriculture, which would allow feeding the urban population, on the one hand, and creating a surplus of workforce in agriculture encouraging the rural residents to move to cities, on the other.

Uniting Eqs 1 and 8 into a system we obtain a mathematical description of the young urban population dynamics.

*Correlation between Young Urban Population Growth Rates and Intensity of Internal Violent Conflicts: A Cross-National Test*

Our cross-national test indicates that violent internal conflicts should be expected in cases when the young urban population grows by more than 30 % during 5 years; if this indicator exceeds 45 % it turns out very difficult for corresponding countries to avoid such upheavals (see Table 4 and Figs 43–45):

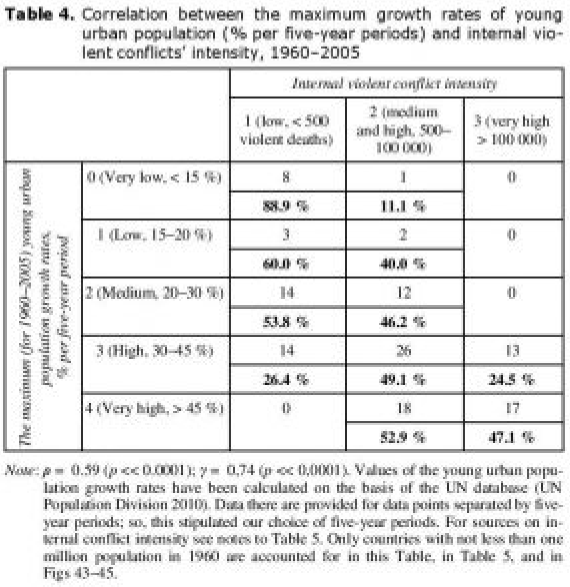


**Table 4.** Correlation between the maximum growth rates of young urban population (% per five-year periods) and internal violent conflicts' intensity, 1960–2005

| | | *Internal violent conflict intensity* | | |
|---|---|---|---|---|
| | | 1 (low, < 500 violent deaths) | 2 (medium and high, 500–100 000) | 3 (very high > 100 000) |
| *The maximum (for 1960–2005) young urban population growth rates, % per five-year period* | 0 (Very low, < 15 %) | 8 | 1 | 0 |
| | | **88.9 %** | **11.1 %** | |
| | 1 (Low, 15–20 %) | 3 | 2 | 0 |
| | | **60.0 %** | **40.0 %** | |
| | 2 (Medium, 20–30 %) | 14 | 12 | 0 |
| | | **53.8 %** | **46.2 %** | |
| | 3 (High, 30–45 %) | 14 | 26 | 13 |
| | | **26.4 %** | **49.1 %** | **24.5 %** |
| | 4 (Very high, > 45 %) | 0 | 18 | 17 |
| | | | **52.9 %** | **47.1 %** |

*Note*: $\rho = 0.59$ ($p << 0.0001$); $\gamma = 0{,}74$ ($p << 0{,}0001$). Values of the young urban population growth rates have been calculated on the basis of the UN database (UN Population Division 2010). Data there are provided for data points separated by five-year periods; so, this stipulated our choice of five-year periods. For sources on internal conflict intensity see notes to Table 5. Only countries with not less than one million population in 1960 are accounted for in this Table, in Table 5, and in Figs 43–45.

**Fig. 43.** Percentage of countries with low (< 500 violent deaths) intensity of internal violent conflicts (for 1960–2005 period) in respective groups*Note*: $\rho =  0.59$ ($p << 0.0001$); $\gamma =  0{,}74$ ($p << 0{,}0001$). Values of the young urban population growth rates have been calculated on the basis of the UN database (UN Population Division 2010). Data there are provided for data points separated by five-year periods; so, this stipulated our choice of five-year periods. For sources on internal conflict intensity see notes to Table 5. Only countries with not less than one million population in 1960 are accounted for in this Table, in Table

5, and in
Figs 43–45.

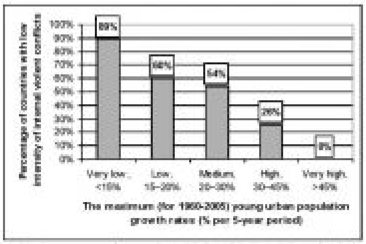


**Fig. 43.** Percentage of countries with low (< 500 violent deaths) intensity of internal violent conflicts (for 1960–2005 period) in respective groups

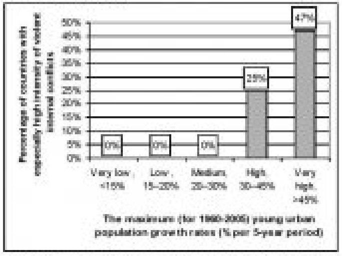


**Fig. 44.** Percentage of countries with very high (> 100,000 violent deaths) intensity of internal violent conflicts (for 1960–2005) in respective groups

The research reveals that for 1960–2005 period the probability of major internal violent political conflicts in countries with very low (less than 15 % increase per five years) young urban population growth rates was very low. For countries with intermediate values of these rates (20–30 % increase per five years) the probability of such conflicts was close to 50 %, that is one chance out of two. However, even for this group of countries there was not a single occurrence of a particularly violent internal political upheaval in the given period. In countries with high (30–45 % increase per five years) young urban population growth rates the probability of avoiding the major internal political upheavals falls down to a very low level (about one chance out of four). Besides, the probability of particularly violent civil wars becomes very high in these countries (also about one chance out of four).

However, particularly deep internal political problems were encountered in those countries in which the young urban population growth rates were very high (> 45 % increase per five years) in the period under consideration. Out of 34 countries of this group NOT A SINGLE ONE managed to avoid major political shocks. Besides, the risk of particularly violent civil war occurrence was very high for these countries (about one chance out of two).

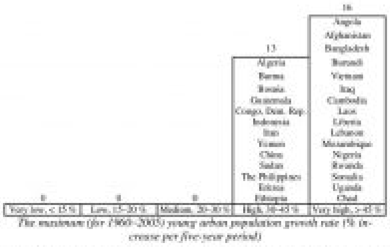


**Fig. 45.** Distribution of countries with an especially high (> 100,000 violent deaths) intensity of violent internal conflicts (for 1960–2005 period) among respective groups

**Table 5.** Internal political conflicts of 1960–2005 that resulted in especially numerous (> 100,000) violent deaths

| № | Country | Year of the beginning | Year of the end | Event | Violent deaths |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | **Algeria** | 1992 | 2002 | Islamist rebellion, civil war | ~100,000 |
| 2 | **Angola** | 1975 | 2002 | Civil war | ~550,000 |
| 3 | **Afghanistan** | 1978 | * | Afghan revolution, civil wars (complicated by foreign interventions) | ~1,800,000 |
| 4 | **Bangladesh** | 1971 | 1971 | War for independence from West Pakistan | ~1,250,000 |
| 5 | **Burma/ Myanmar** | Before 1960 | * | Civil wars | ~130,000 |
| 6 | **Bosnia and Herzegovina** | 1992 | 1995 | The Bosnian civil war | ~175,000 |
| 7 | **Burundi** | 1993 | 1993 | Civil war, mass killings of *hutu* and *tutsi* (mainly hutu were killed) | ~200,000** |
| 8 | **Vietnam** | 1965 | 1973 | Civil war in South Vietnam with interventions on the part of the USA and North Vietnam | ~1,700,000 |
| 9 | **Guatemala** | 1960 | 1996 | Civil war | ~200,000 |
| 10 | **Congo, Dem. Rep. (Zaire)** | 1960 | 1965 | Congolese crisis | ~100,000 |
|  |  | 1998 | 2009 | Civil wars | ~3,800,000 |
| 11 | **Indonesia** | 1965 | 1966 | Coup attempt, mass executions | ~400,000 |
| 12 | **Iraq** | 1961 | * | Kurd uprisings in the north, Shia insurrections in the south, political upheavals of the 2000s | ~100,000 |
| 13 | **Iran** | 1978 | 1979 | Islamic revolution | ~100,000 |
| 14 | **Yemen** | 1962 | 1970 | Revolution and civil war | ~100,000 |
| 15 | **Cambodia** | 1970 | 1991 | Civil wars and their consequences (complicated by foreign interventions) | ~2,500,000 |
| 16 | **China** | 1966 | 1969 | 'Cultural revolution' | From 2,000,000 to 7,000,000 |
| 17 | **Laos** | 1960 | 1973 | Civil war within the Second Indochina War | From 70,000 to 250,000 |
| 18 | **Liberia** | 1989 | 1997 | Civil wars | ~150,000 |
| 19 | **Lebanon** | 1975 | 1990 | Civil war complicated by numerous cases of foreign intervention | ~150,000 |
| 20 | **Mozambique** | 1975 | 1992 | Civil war | ~1,000,000 |
| 21 | **Nigeria** | 1966 | 1970 | Coup, civil war of Biafra | From 600,000 to 1,000,000 |
| 22 | **Rwanda** | 1994 | 1994 | Civil war, mass killings of the Tutsi | ~937,000** |
| 23 | **Somalia** | 1991 | * | Civil war, state breakdown, chaos, anarchy | ~400,000** |
| 24 | **Sudan** | 1955 | 1972 | Civil war | ~500,000 |
|  |  | 1983 | * | Civil war | ~1,900,000 |
|  |  | 2003 | * | Darfur conflict | From 70,000 to more than 180,000 |
| 25 | **Uganda** | 1979 | 1986 | Civil wars | ~300,000** |
| 26 | **The Philippines** | Since 1972 | * | War against guerrillas | From 50,000 to 150,000 |
| 27 | **Chad** | 1965 | 1997 | Civil wars | From 50,000 to 100,000 |
| 28 | **Eritrea** | 1962 | 1992 | War for independence and internal conflicts | ~1,400,000 |
| 29 | **Ethiopia** | 1962 | 1992 | Civil wars | ~1,400,000† |

*Note:* * Events unfinished, violence continuing in some form.

*Sources:* Grinin and Korotayev 2009; Bercovitch and Jackson 1997; Clodfelter 1992; Crowder, Fage, and Oliver 1986; Lorraine 1995; Palmowski 1997; Project Ploughshares 2008; Rummel 1994; Small and Singer 1982; Totten 1997; Wallechinsky 1995; White 2010a; 2010b.

## *Forecasting the Dynamics of Sociopolitical Instability in the African Countries in 2020–2050*

The results obtained in our research can well be used for predicting the risks of sociopolitical instability for the countries being on the verge of escaping from the Malthusian trap, in the process of escape, or having escaped from it recently.

Working out of such forecasts is currently made remarkably easier by the fact that UN Population Division has developed urbanization dynamics forecasts for all the African countries, as well as age structure dynamics forecasts up to 2050 (UN Population Division 2010). Synthesis of these predictions allowed us to make a synthetic forecast regarding the dynamics of structural-demographic instability for the African countries in this period.

It is noteworthy that in our prediction only 'positive results' are really significant (*i.e.* the results revealing the presence of high political instability risk in a certain country in a certain period). We are inclined to interpret such results as an evidence of a real risk of political instability in the given place at the given time (if, of course, respective governments do not undertake adequate measures in proper time). On the other hand, in our opinion, 'negative results' cannot be viewed as a guarantee of absence of political upheavals in the given country up to 2050 (as we do not claim that the reasons of violent political upheavals can be reduced to structural-demographic factors only).

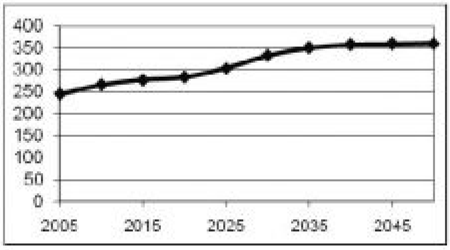


**Fig. 46.** Young urban population dynamics (thousands) in Botswana, forecast up to 2050

Our forecast has produced rather different results for different Subsaharan African countries.

No serious demographic structural risks of the type in questions are forecasted after 2015 for some Subsaharan countries (especially in Southern Africa). Let us regard, for example, the forecast for Botswana (see Fig. 46):

No serious structural-demographic risks of this type are forecasted for many countries of Tropical Africa, for example, Gabon (see Fig. 47):

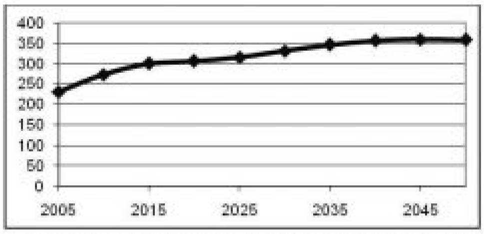


**Fig. 47.** Young urban population dynamics (thousands) in Gabon, forecast up to 2050

While in the Gabon case the young urban population growth curve quite clearly demonstrates the absence of major structural-demographic risks, for some other Tropical African countries it is necessary (in order to detect it) to carry out an analysis of time series generated by our forecast. A bright example here is represented by the Ghana case (see Fig. 48).

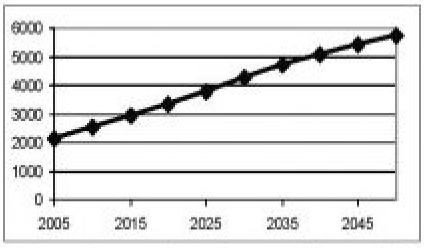


**Fig. 48.** Young urban population dynamics (thousands) in Ghana, forecast up to 2050

Indeed, in application to Ghana the forecasted situation may seem truly threatening, as by 2050 the young urban population there is likely to grow almost threefold (*i.e.*, 200 %; while in the cases considered above this growth did not exceed 50 %).

However, a simple analysis of the corresponding time series shows that the situation is not so threatening. Indeed, the forecasted dynamics of relative growth rates of the young urban population has the following shape (Fig. 49).

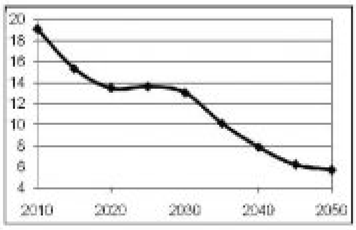


**Fig. 49.** Forecasted dynamics of relative growth rates of the young urban population in Ghana up to 2050, % per five-year periods

Thus, in the following decade urban youth relative growth rates are forecasted to be decreasing in Ghana up to a quite safe level of less than 14 % during five years; in the 2020s these rates are going to stabilize (at the same rather safe level), while after 2030 they will decline further on. A similar dynamics is demonstrated by the absolute growth rates of the young urban population (see Fig. 50).

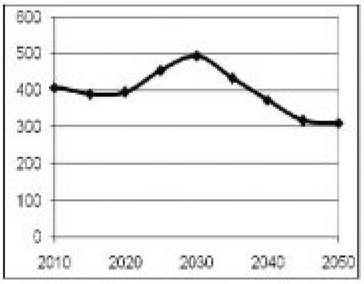


**Fig. 50.** Forecasted dynamics of absolute growth rates (in thousands) of the young urban population in Ghana up to 2050, per five-year periods

Thus, no increase in absolute growth rates of the young urban population is forecasted in Ghana for the next decade. According to the same forecast, a certain increase in these rates is expected in the 2020s, but it will be very moderate (25 % during ten years). After 2030 the absolute growth rates are forecasted to start declining, and by the 2040s they are expected to fall below the current level.

However, the forecast indicates the presence of high structural-demo-graphic risks for a wide range of Tropical African countries (see Table 6 below for a full list). Fortunately, in no case the urban youth growth rates are forecasted to exceed the critical level of 45 % per five years (let us remember that in the recent decades not a single country which crossed this level managed to avoid major internal sociopolitical conflicts, while in half of the cases particularly violent internal political upheavals occurred). Along with that, a number of tropical African countries are forecasted to get into a very dangerous zone of 30–45 % (let us remember that in the recent decades only a quarter of countries found in this zone managed to avoid major internal political conflicts, while in a quarter of cases particularly violent internal political upheavals were observed).

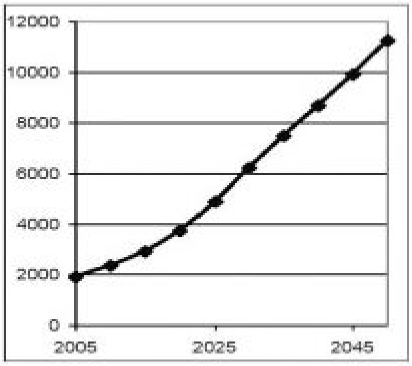


**Fig. 51.** Young urban population dynamics in Tanzania up to 2050, thousands

Tanzania is among the countries of high structural-demographic risk.

The general dynamics of the urban population in this country is forecasted as follows (see Fig. 51):

Thus, in 2005–2050 an almost six-fold increase in the young urban population is forecasted for Tanzania, while in the 2020s the relative growth rates of this indicator will exceed the critical level of 30 % per five years.

However, the most serious structural-demographic risks are predicted for Niger (see Fig. 52):

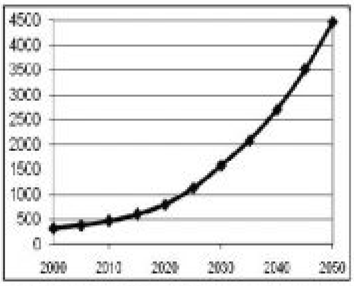


**Fig. 52.** Young urban population dynamics in Niger up to 2050, thousands

Thus, in 2000–2050 the young urban population of Niger will increase by an order of magnitude, while in the second half of the 2010s the relative growth rates of this indicator will exceed the critical level of 30 % per five years, while in the early 2020s they will exceed an even more dangerous level of 40 % during five years. These rates will decrease to relatively safe levels only in the late 2040s (see Fig. 53).

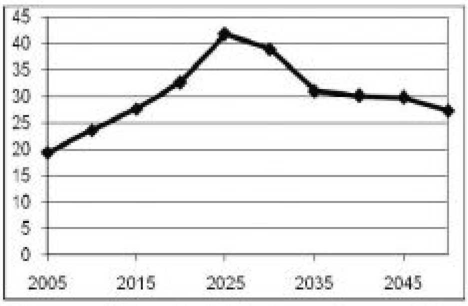


**Fig. 53.** Forecasted dynamics of relative growth rates of the young urban population in Niger up to 2050, % per five-year periods

Besides, in Niger an increase by an order of magnitude (in comparison to 2000 level) in the absolute growth rates of the young urban population is forecasted by 2030 (see Fig. 54).

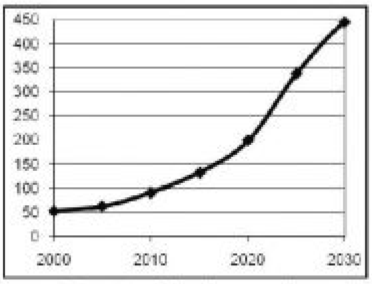


**Fig. 54.** Forecasted dynamics of absolute growth rates (in thousands) of the young urban population in Niger up to 2050, per five-year periods

In conclusion, let us present a summary forecast of structural-demographic risks of political destabilization in the Subsaharan African countries up to 2050 (see Table 6).

| *Country* | *Years of maximum urban youth growth rates* | Urban youth growth rates (% in five years) in those years | *Period of particularly high structural-demographic risks of political destabilization* | *Structural-demographic risk level* |
|---|---|---|---|---|
| Niger | 2021–2025 | 41.8 | 2021–2030 | Very high |
| Malawi | 2016–2020 | 39 | 2015–2025 | High |

| *Country* | *Years of maximum urban youth growth rates* | Urban youth growth rates (% in five years) in those years | *Period of particularly high structural-demographic risks of political destabilization* | *Structural-demographic risk level* |
|---|---|---|---|---|
| Burkina Faso | 2021–2025 | 38.7 | 2021–2030 | High |
| Uganda | 2021–2025 | 33.1 | 2021–2030 | High |
| Eritrea | 2021–2025 | 32.5 | 2021–2030 | High |
| Tanzania | 2021–2025 | 30.6 | 2021–2030 | High |
| Kenya | 2021–2025 | 30.2 | 2021–2030 | High |
| Rwanda | 2021–2025 | 29.6 | 2021–2030 | Medium |
| Chad | 2016–2020 | 28.5 | 2016–2025 | Medium |
| Burundi | 2026–2030 | 28.1 | 2026–2035 | Medium |
| Congo, Dem. Rep. | 2016–2020 | 27.7 | 2016–2025 | Medium |
| Mozambique | 2021–2025 | 27.4 | 2021–2030 | Medium |
| Somalia | 2016–2020 | 27.4 | 2016–2025 | Medium |
| Ethiopia | 2016–2020 | 26.7 | 2016–2025 | Medium |
| Gambia | 2016–2020 | 26.5 | 2016–2025 | Medium |
| Sierra Leone | 2016–2020 | 25.4 | 2016–2025 | Medium |
| Madagascar | 2016–2020 | 25.2 | 2016–2020 | Medium |

*Table 6*

NOTES

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[1] This is a modified and extended version of the article originally published in *Cliodynamics* (A Trap at the Escape from the Trap? Demographic-Structural

Factors of Political Instability in Modern Africa and West Asia. *Cliodynamics* 2(2) (2011): 1–28. URL: http://escholarship.org/uc/item/ 79t737gt).

[2] Using the terminology of non-linear dynamics one can also denote it as *the low-level equilibrium attractor* (cf. Nelson 1956).

[3] This was already noticed, for example, by Mann: 'The … decline in population growth during the nineteenth century owed much to a rise in female infanticide, itself a direct response to declining economic opportunity' (Mann 2002: 451).

[4] Note that the colossal sweep of their rebellion was determined up to a very significant degree just by Malthusian factors.

[5] Naturally, the 1997 sociopolitical collapse led to a certain decline in the average per capita food consumption (below 2700 kcal per day), which was still above the level recommended by the WHO; whereas later the growth of this indicator resumed (FAO 2014).

[6] Note that, as these are young males (rather than females) that tend to migrate from the rural to urban areas, we have an especially explosive growth of young *male* urban population, which has a particularly destabilizing effect.

[7] General number of deaths in Ethiopia and Eritrea in 1962–1992.

[8] **مشكلة السكان فى مصر، دراسة اجتماعية اقتصادية / تأليف صلاح الدين نامق.** القاهرة: مكتبة النهضة المصرية، 1952.

*References*

*Abrahamian E. 2008. A History of Modern Iran*. Cambridge, UK: Cambridge University Press.

*Adejumobi S. A. 2007. The History of Ethiopia*. Westport, CT: Greenwood.

*Akaev A. A. 2010.* Modern Financial and Economic Crisis in the Light of the Theory of the Economy's Innovative and Technological Development of Economy and Controlling of Innovative Process. *System Monitoring of Global and Regional Development* / Ed. by D. A. Khaltourina, and A. V. Korotayev, pp. 230–258. Moscow: Librokom. *In Russian* (Акаев А. А. Современный финансово-экономический кризис в свете теории инновационно-технологического развития экономики и управления инновационным процессом. *Системный мониторинг глобального и регионального развития* / Ред. Д. А. Халтурина, А. В. Коротаев, с. 230–258. М.: Либроком/URSS).

*Akokpari J. 2007.* 'You Don't Belong Here': Citizenship and Africa's Conflicts – Reflections on Ivory Coast. *African Conflicts: Management, Resolution and Post-*

*conflict Recovery and Development* / Ed. by P. Zeleza, pp. 88–105. Oxford: James Currey.

*Artzrouni M., and Komlos J. 1985.* Population Growth through History and the Escape from the Malthusian Trap: A Homeostatic Simulation Model. *Genus* 41(3–4): 21–39.

*Bray F. 1984.* Biology and Biological Technology. Part 2, Agriculture. *Science and Civilisation in China* / ed. by J. Needham. vol. 6. p. 2. Cambridge, UK; New York: Cambridge University Press.

*Bercovitch J., and Jackson R. 1997. International Conflict: A Chronological Encyclopedia of Conflicts and Their Management, 1945–1995.* Washington: Congressional Quarterly.

*Chao Kang. 1986. Man and Land in Chinese History. An Economic Analysis.* Stanford, CA: Stanford University Press.

*Chesnais J. C. 1992. The Demographic Transition: Stages, Patterns, and Economic Implications.* Oxford: Clarendon Press.

*Chu C. Y. C., and Lee R. D. 1994.* Famine, Revolt, and the Dynastic Cycle: Population Dynamics in Historic China. *Journal of Population Economics* 7: 351–378.

*Cleveland W. 1936. The Population Problem in Egypt. A Study of Population Trends and Conditions in Modern Egypt.* Lancaster, PN: Science Press.

*Clodfelter M. 1992. Warfare and Armed Conflict: A Statistical Reference to Casualty and Other Figures, 1618–1991.* 2 vols. London: McFarland.

*Craig J. I. 1917.* The Census of Egypt. *L'Egypte Contemporaine* 8: 209–234.

*Crowder M., Fage J. D., and Oliver R. (Eds.) 1986. The Cambridge History of Africa.* Vol. 8. New York: Cambridge University Press.

*Dikarev A. D. 1991.* Some Problems of Growth and Records of Population in the Sin Epoch. *Social-Economic and Political Problems of China in the New and Modern Ages* / Ed. by G. D. Sukharchuk, pp. 58–91. Moscow: Nauka. *In Russian* (Дика-рев А. Д. Некоторые проблемы роста и учёта населения в эпоху Цин. *Социально-экономические и политические проблемы Китая в новое и новейшее время* / Ред. Г. Д. Сухарчук, с. 58–91. М.: Наука).

*Fairbank J. K. 1992. China: A New History.* Cambridge, MA: Belknap.

*FAO (Food and Agriculture Organization of the United Nation). 2014. FAOSTAT. Food and Agriculture Organization Statistics.* URL: http://faostat.fao.org/.

*Fisk R. 1990. Pity the Nation.* London: Touchstone.

*Foerster H. von, Mora P., and Amiot L. 1960.* Doomsday: Friday, 13 November, A.D. 2026. *Science* 132: 1291–1295.

*Frenkel M. Yu. 1999. History of Liberia in the Modern and Contemporary Era.*

Moscow: Vostochnaya literatura. *In Russian* (Френкель М. Ю. *История Либерии в новое и новейшее время*. М.: Восточная литература).

*Friedman T. 1998. From Beirut to Jerusalem*. London: HarperCollins.

*Fuller G. E. 2004. The Youth Crisis in Middle Eastern Society*. Clinton Township, MI: Institute for Social Policy and Understanding.

*Goldstone J. 1991. Revolution and Rebellion in the Early Modern World*. Berkeley, CA: University of California Press.

*Goldstone J. 2002.* Population and Security: How Demographic Change Can Lead to Violent Conflict. *Journal of International Affairs* 56(1): 3–22.

*Goldstone J. A., Gurr T. R., Harff B., Levy M. A., Marshall M. G., Bates R. H., Epstein D. L., Kahl C. H., Surko P. T., Ulfelder J. C., Unger Jr., and Unger A. N. 2000. State Failure Task Force Report: Phase III Findings.* McLean, VA: Science Applications International Corporation (SAIC). URL: http://www.cidcm.umd.edu/inscr/stfail/.

*Grinin L. E. 2006. Productive Forces and Historical Process.* 4th ed. Moscow: URSS. *In Russian* (Гринин Л. Е. *Производительные силы и исторический процесс.* 4-е изд. М.: УРСС).

*Grinin L. E. 2007.* Some Reflections Concerning the Nature of Laws Connected with Demographic Cycles (Raising the Question of Common Methodological Approaches to the Analysis of Demographic Cycles). *History and Mathematics: Conceptual Space and Courses of Search* / P. V. Turchin, L. E. Grinin, S. Yu. Malkov, and A. V. Korotayev (eds.), pp. 219–246. Moscow: LKI/URSS. *In Russian* (Гринин Л. Е. Некоторые размышления по поводу природы законов, связанных с демографическими циклами (к постановке проблемы определения общих методологических подходов к анализу демографических циклов). *История и математика: Концептуальное пространство и направления поиска* / Ред. П. В. Турчин, Л. Е. Гринин, С. Ю. Малков, А. В. Коротаев, с. 219–246. М.: ЛКИ/URSS).

*Grinin L. E. 2010.* Malthusian-Marxian Trap and the Russian Revolutions. *History and Mathematics. On the Causes of the Russian Revolution* / Ed. by L. E. Grinin, A. V. Korotayev, S. Yu. Malkov, pp. 368–427. Moscow: LKI/URSS. *In Russian*. (Гринин Л. Е. Мальтузианско-марксова «ловушка» и русские революции. *История и математика. О причинах Русской революции* / Ред. Л. Е. Гринин, А. В. Коротаев, С. Ю. Малков, с. 198–224. М.: ЛКИ/URSS).

*Grinin L. E., and Korotayev A. V. 2009.* Urbanization and Political Instability: Working out Mathematical Models of Political Processes. *Polis* 4: 34–52. *In*

*Russian* (Гринин Л. Е., Коротаев А. В. Урбанизация и политическая нестабильность: к разработке математических моделей политических процессов. *Политические исследования* 4: 34–52).

*Grinin L., and Korotayev A. 2012.* Does 'Arab Spring' Mean the Beginning of World System Reconfiguration? *World Futures* 68(7): 471–505.

*Grinin L. E., Korotayev A. V., and Malkov S. Yu. 2008.* Mathematical Models of Socio-Demographic Cycles and Escape from the Malthusian Trap. *Problems of Mathematical History: Mathematical Modeling of Historical Processes* / Ed. by G. G. Malinetsky and A. V. Korotayev, pp. 78–117. Moscow: URSS. *In Russian* (Гринин Л. Е., Коротаев А. В., Малков С. Ю. Математические модели социально-демографических циклов и выхода из мальтузианской ловушки. Проблемы математической истории. *Математическое моделирование исторических процессов* / Ред. Г. Г. Малинецкий, А. В. Коротаев, с. 78–117. М.: URSS).

*Grinin L. E., Malkov S. Yu., Gusev V. A., and Korotayev A. V. 2009.* Possible Directions for Further Development of Socio-Demographic Cycle Theory and Mathematical Models of the Escape from the Malthusian Trap. *History & Mathematics: Processes & Models* / Ed. by S. Yu. Malkov, L. E. Grinin, and A. V. Korotayev (eds.), pp. 134–210. Moscow: URSS. *In Russian* (Гринин Л. Е., Малков С. Ю., Гусев В. А., Коротаев А. В. Некоторые возможные направления развития теории социально-демографических циклов и математические модели выхода из мальтузианской ловушки. *История и Математика: процессы и модели* / Ред. С. Ю. Малков, Л. Е. Гринин, А. В. Коротаев, с. 134–210. М.: URSS).

*Haldane J. T. 1989.* Weak Oil Market Hampering Arab Development Efforts. *Washington Report on Middle East Affairs* January: 39.

*Heijdra M. 1998.* The Socio-Economic Development of Rural China during the Ming. Twitchett, D., and Mote, F. W. (eds.), *The Cambridge History of China.* Vol. 8. *The Ming Dynasty, 1368–1644.* Part II, pp. 417–578. Cambridge: Cambridge University Press.

*Heinsohn G. 2003. Söhne und Weltmacht. Terror im Aufstieg und Fall der Nationen.* Zürich: Orell Füssli Verlag.

*Hirst D. 1977.* How High Life and Scandal Rocked Sadat. *MERIP Reports* 54: 19–20.

*Ho Ping-ti. 1955.* The Introduction of American Food Plants into China. *American Anthropologist* 57: 191–201.

*Ho Ping-ti. 1959. Studies on the Population of China, 1368–1953.* Cambridge, MA:

Harvard University Press.

*Huang P. C. C. 2002.* Development or Involution in Eighteenth-Century Britain and China? *The Journal of Asian Studies* 61: 501–538.

*Huband M. 1998. The Liberian Civil War*. London: Frank Cass.

*Ilyushechkin V. P. 1967. The Taipings' Peasant War.* Moscow: Nauka. *In Russian* (Илюшечкин В. П. *Крестьянская война тайпинов.* М.: Наука).

*Jarvis C. 1999. The Rise and Fall of the Pyramid Schemes in Albania*. IMF Working Paper 99/98.Washington: International Monetary Fund.

*Jomard E. F. 1818.* Mémoire sur la population contemporaine de l'Egypte ancienne et moderne. Description de l'Égypte, ou, Recueil de observations et des recherches qui ont été faites en Égypte pendant l'éxpédition de l'armée française / Ed. E. F. Jomard. Vol. II–1, pp. 87–142. Paris: Imprimerie impériale.

*Kepel G. 2004. The Jihad. The Expansion and Decline of Islam.* Moscow: Ladomir. *In Russian* (Кепель, Ж. *Джихад. Экспансия и закат исламизма.* М.: Ладомир).

*Kepel G. 2006. Jihad: The Trail of Political Islam.* 4th ed. London: Tauris.

*van Kessel-Hagesteijn R. 2009***.** Dynamics in Political Centralization Processes – The Various Faces of 'Decline'. *International Symposium on Early State Formation Handbook,* pp. 46–63. Peking: National Academy of China.

*Kögel T., and Prskawetz A. 2001.* Agricultural Productivity Growth and Escape from the Malthusian Trap. *Journal of Economic Growth* 6: 337–357.

*Komlos J., and Artzrouni M. 1990.* Mathematical Investigations of the Escape from the Malthusian Trap. *Mathematical Population Studies* 2: 269–287.

*Komlos J., and Nefedov S. 2002.* A Compact Macromodel of Pre-industrial Population Growth. *Historical Methods* 35: 92–94.

*Korotayev A. 2006.* The World System Urbanization Dynamics: A Quantitative Analysis. *History & Mathematics: Historical Dynamics and Development of Complex Societies* / Ed. by P. Turchin, L. Grinin, A. Korotayev, and V. C. de Munck, pp. 44–62. Moscow: KomKniga/URSS.

*Korotayev A., and Khaltourina D. 2006. Introduction to Social Macrodynamics: Secular Cycles and Millennial Trends in Africa*. Moscow: KomKniga/URSS.

*Korotayev A. V., Khaltourina D. A., Malkov A. S., Bogevolnov J. V., Kobzeva S. V., and Zinkina J. V. 2010. Laws of History: Mathematical Modeling and Forecasting World and Regional Development.* Moscow: URSS. *In Russian* (Коротаев А. В., Халтурина Д. А., Малков А. С., Божевольнов Ю. В., Кобзева С. В., Зинькина Ю. В. *Законы истории. Математическое моделирование и прогнозирование мирового и регионального развития.* 3rd ed. М.: URSS).

*Korotayev A., Malkov A., and Khaltourina D. 2006a. Introduction to Social Macrodynamics: Compact Macromodels of the World System Growth*. Moscow: URSS.

*Korotayev A., Malkov A., and Khaltourina D. 2006b. Introduction to Social Macrodynamics: Secular Cycles and Millennial Trends*. Moscow: KomKniga/URSS.

*Korotayev A. V., Komarova N. L., and Khaltourina D. A. 2007. Laws of History: Secular Cycles and Millennial Trends.* Moscow: URSS. *In Russian* (Коротаев А. В., Комарова Н. Л., Халтурина Д. А. *Законы истории. Вековые циклы и тысячелетние тренды.* М.: URSS).

*Korotayev A., and Zinkina J. 2011.* Egyptian Revolution: A Demographic Structural Analysis. *Entelequia. Revista Interdisciplinar* 13: 139–169.

*Kuhn P. A. 1978.* The Taiping Rebellion. *The Cambridge History of China.* Vol. 1. *Late Ch'ing, 1800 – 1911*. Part 1 / Ed. by D. Twitchett, and J. K. Fairbank, pp. 264–317. Cambridge, UK: Cambridge University Press.

*Kulpin E. S. 1990. Man and Nature in China.* Moscow: Nauka. *In Russian* (Кульпин Э. С. *Человек и природа в Китае*. М.: Наука).

*Larin V. L. 1986. Rebellion of Peoples of Southwestern China in the 1850s – 1870s.* Moscow: Nauka. *In Russian* (Ларин В. Л. *Повстанческая борьба народов Юго-Западного Китая в 50–70-х годах XIX века.* М.: Наука).

*Lavely W., and Wong R. B. 1998.* Revising the Malthusian Narrative: The Comparative Study of Population Dynamics in Late Imperial China. *The Journal of Asian Studies* 57: 714–748.

*Lee J. 1982.* Food Supply and Population Growth in South-West China, 1250–1850. *Journal of Asian Studies* 41: 711–746.

*Lee J., Campbell C., and Guofu Tan. 1992.* Infanticide and Family Planning in Late Imperial China: The Price and Population History of Rural Liaoning, 1774–1873. *Chinese History in Economic Perspective* / Ed. by T. G. Rawski, L. M. Li, pp. 145–176. Berkeley, CA: University of California Press.

*Lee J., and Wang Feng. 1999. One Quarter of Humanity: Malthusian Mythology and Chinese Realities, 1700–2000*. Cambridge, MA: Harvard University Press.

*Lewis L. S. 2002. Laying Claim to the Memory of May: A Look Back at the 1980 Kwangju Uprising*. Honolulu, HI: University of Hawaii Press.

*Liu Kwang-Ching. 1978.* The Ch'ing Restoration. *The Cambridge History of China.* Vol. 10. Part 1. *Late Ch'ing, 1800 –1911* / Ed. by D. Twitchett, J. K. Fairbank, pp. 409–490. Cambridge, UK: Cambridge University Press.

*Lorraine G. (Ed.) 1995. Our Times: The Illustrated History of the 20th Century.*

New York: Turner.

*Maddison A. 2001. Monitoring the World Economy: A Millennial Perspective.* Paris: OECD.

*Maddison A. 2010. World Population, GDP and Per Capita GDP, A.D. 1–2003.* URL: www.ggdc.net/maddison.

*Malkov S. Yu. 2002.* Mathematical Modeling of Historical Processes. The New Ideas in Synergetics. *Vision of the Third Millennium* / Ed. by G. G. Malinetsky, and S. P. Kurdyumov, pp. 291–323. Moscow: Nauka. *In Russian* (Малков С. Ю. Математическое моделирование исторических процессов. *Новое в синергетике. Взгляд в третье тысячелетие* / Ред. Г. Г. Малинецкий, С. П. Курдюмов, с. 291–323. М.: Наука).

*Malkov S. Yu. 2003.* Mathematical Modeling of Social Processes Dynamics. *Links of Times* / Ed. by I. L. Zherebtsov. Vol. 2, pp. 190–214. Moscow: MGVP KOKS. *In Russian* (Малков С. Ю. Математическое моделирование динамики общественных процессов. *Связь времен* / Ред. И. Л. Жеребцов. Т. 2, с. 190–214. М.: МГВП КОКС).

*Malkov S. Yu. 2004.* Mathematical Modeling of the Historical Dynamics: Approaches and Models. *Modeling the Socio-political and Economic Dynamics* / Ed. by M. G. Dmitriyev, pp. 76–188. Moscow: Russian State University for Social Studies. *In Russian* (Малков С. Ю. Математическое моделирование исторической динамики: подходы и модели. *Моделирование социально-политической и экономической динамики* / Ред. М. Г. Дмитриев, с. 76–188. М.: РГСУ).

*Malkov S. Yu. 2009. Social Self-Organization and Historical Process: Potentials of Mathematical Modelling.* Moscow: Librokom/URSS. *In Russian* (Малков С. Ю. *Социальная самоорганизация и исторический процесс: возможности математического моделирования.* М.: Либроком/URSS).

*Malkov S. Yu., Kosse Yu. V., Bakulin V. N., and Sergeyev A. V. 2002.* Social-Economic and Demographic Dynamics in Agrarian Societies. *Matematicheskoye modelirovaniye* 14(9): 103–108. *In Russian* (Малков С. Ю., Коссе Ю. В., Баку-лин В. Н., Сергеев А. В. Социально-экономическая и демографическая динамика в аграрных обществах. *Математическое моделирование* 14(9): 103–108).

*Malkov S. Yu., Kovalyov V. I., and Malkov A. S. 2000.* The History of Mankind and Stability (Mathematical Modelling). *Strategicheskaya stabilnost* 3: 53–66. *In Russian* (Малков С. Ю., Ковалев В. И., Малков А. С. История человечества и стабильность (опыт математического моделирования). *Стратегическая стабильность* 3: 52–66).

*Malkov S. Yu., and Malkov A. S. 2000.* History in the Context of Mathematical Modelling. *History For and Against History* / Ed. by Yu. M. Osipov, I. V. Bestuzhev-Lada, E. S. Zotova, and G. R. Naumova. Vol. 2, pp. 54–76. Moscow: Centre for Social Sciences. *In Russian* (Малков С. Ю., Малков А. С. История в свете математического моделирования. *История за и против истории* / Ред. Ю. М. Осипов, И. В. Бестужев-Лада, Е. С. Зотова, Г. Р. Наумова. кн. 2, с. 54–76. М.: Центр общественных наук).

*Malkov S. Yu., Selunskaya N. B., and Sergeyev A. V. 2005.* Socioeconomic and Demographic Processes in Agrarian Society as an Object of Mathematical Modeling. *History and Synergetics: Mathematical Modeling of Social Dynamics* / Ed. by S. Yu. Malkov, and A. V. Korotayev, pp. 70–87. Moscow: URSS. *In Russian* (Малков С. Ю., Селунская Н. Б., Сергеев А. В. Социально-экономические и демографические процессы в аграрном обществе как объект математического моделирования. *История и синергетика: Математическое моделирование социальной динамики* / Ред. С. Ю. Малков, А. В. Коротаев, с. 70–87. М.: КомКнига/ URSS).

*Malkov S. Yu., and Sergeyev A. V. 2002.* Mathematical Modeling of Social Economic Stability of Developing Society. *Strategucheskaya stabilnist* 4: 54–61. *In Russian* (Малков С. Ю., Сергеев А. В. Математическое моделирование социально-экономической устойчивости развивающегося общества. *Стратегическая стабильность* 4: 54–61).

*Malkov S. Yu., and Sergeyev A. V. 2004a. Mathematical Modeling of Economic and Demographic Processes in Agrarian Societies.* Moscow: Keldysh Institute of Applied Mathematics. *In Russian* (Малков С. Ю., Сергеев А. В. *Математическое моделирование экономико-демографических процессов в аграрном обществе.* М.: Институт прикладной математики им. М. В. Келдыша РАН).

*Malkov S. Yu., and Sergeyev A. V. 2004b.* Assessment of Stability of Social Systems Based on Economic-Demographical Modeling. *The Problems of Complex Systems Safety Management* / Ed. by N. I. Arkhipova, V. V. Kulba, pp. 356–359. Moscow: RGGU. *In Russian* (Малков С. Ю., Сергеев А. В. Оценка устойчивости социальных систем на основе экономико-демографического моделирования. *Проблемы управления безопасностью сложных систем* / Ред. Н. И. Архипова, В. В. Кульба, с. 356–359. М.: РГГУ).

*Malthus T. 1798. An Essay on the Principle of Population, as It Affects the Future Improvement of Society, with Remarks on the Speculations of Mr Godwin, M. Condorcet and Other Writers*. London: J. Johnson.

*Malthus T. 1978 [1798]. Population: The First Essay.* Ann Arbor, MI: University of

Michigan Press.

*Mann S. 2002.* Women, Families, and Gender Relations. *The Cambridge History of China.* Vol. 9. Part 1. *The Ch'ing Empire to 1800* / Ed. by W. J. Peterson, pp. 428–472. Cambridge, UK: Cambridge University Press.

*McCarthy J. A. 1976.* Nineteenth-Century Egyptian Population. *Middle Eastern Studies* 12(3): 1–39.

*McKendrick A. G. 1926. Applications of Mathematics to Medical Problems. Proceedings of the Edinburgh Mathematical Society* 44: 98–130.

*Mesquida C. G., and Weiner N. I. 1999.* Male Age Composition and Severity of Conflicts. *Politics and the Life Sciences* 18: 113–117.

*Moller H. 1968.* Youth as a Force in the Modern World. *Comparative Studies in Society and History* 10: 238–260.

*Montgomery T. S. 1995. Revolution in El Salvador: From Civil Strife to Civil Peace*. Boulder, CO: Westview Press.

*Mote F. W. 1999. Imperial China 900–1800.* Cambridge, MA: Harvard University Press.

*Murguzin A. S. 1986.* Role of Natural and Demographical Factors in Dynamics of Medieval China's Agrarian Sector (on the Problem of Cyclicity of Precapitalist Reproduction). *Historical Factors of Social Reproduction in the Eastern Countries* / ed. by L. I. Reisner, B. I. Slavnyi, pp. 11–44. Moscow: Nauka. *In Russian* (Мугрузин А. С. Роль природных и демографических факторов в динамике аграрного сектора средневекового Китая (к вопросу о цикличности докапиталистического воспроизводства). *Исторические факторы общественного воспроизводства в странах Востока* / Ред. Л. И. Рейснер, Б. И. Славный, с. 11–44. М.: Наука).

*Murguzin A. S. 1994***.** *The Agrarian-Peasant Problem in China.* Moscow: Nauka. *In Russian* (Мугрузин А. С. *Аграрно-крестьянская проблема в Китае.* М.: Наука).

*Myers R. H., and Wang Yeh-chien. 2002.* Economic Developments, 1644–1800. *The Cambridge History of China.* Vol. 9. Part 1. *The Ch'ing Empire to 1800* / Ed. by W. J. Peterson, pp. 563–645. Cambridge, UK: Cambridge University Press.

*Naiken L. 2002. FAO methodology for estimating the prevalence of undernourishment*. Paper presented at International Scientific Symposium on Measurement and Assessment of Food Deprivation and Undernutrition, Rome, Italy. URL: www.fao.org.

*Nāmiq Ṣalāḥ al-Dīn. 1952. Mushkilat al-sukkān fī Miṣr: dirāsah ijtimāʿiyyah* *iqtiṣādiyyah*. al-Qāhirah: Maktabat al-Nahḍah al-Miṣriyyah.[8]

*Nefedov S. A. 1999a. The Method of Demographic Cycles in Research of Socio-Economic History of Pre-industrial Society.* PhD Thesis (history). Ekaterinburg: Ural State University. *In Russian* (Нефедов С. А. *Метод демографических циклов в изучении социально–экономической истории допромышленного общества*. Автореферат дис. … канд. ист. наук. Екатеринбург: Уральский государственный университет).

*Nefedov S. A. 1999b. On Demographic Cycles in Babylonia's History*. Manuscript. Moscow. URL: http://www.hist1.narod.ru/ Science/ Babilon/Vavilon.html. *In Russian* (Нефедов С. А. *О демографических циклах в истории Вавилонии.* Рукопись (#54930), депонированная в ИНИОН РАН, М. URL: http://www.hist1.narod.ru/ Science/ Babilon/Vavilon.html).

*Nefedov S. A. 1999c. On Demographic Cycles in Ancient Egypt's History*. Manuscript. Moscow. URL: http://www.hist1.narod.ru/ Science/ Egipt/Egipt.html. *In Russian* (Нефедов С. А. *О демографических циклах в истории Древнего Египта.* Рукопись (#54931), депонированная в ИНИОН РАН, М. URL: http://www.hist1. narod.ru/ Science/ Egipt/Egipt.html).

*Nefedov S. A. 1999d. On Demographic Cycles in Medieval China's History*. Manuscript. Moscow. URL: http://www.hist1.narod.ru/ Science/ China/China.html. *In Russian* (Нефедов С. А. *О демографических циклах в средневековой истории Китая.* Рукопись (#54932), депонированная в ИНИОН РАН, М. URL: http://www.hist1.narod.ru/ Science/ China/China.html).

*Nefedov S. A. 1999e. An Attempt of Imitation Modeling Demographic Cycles.* Manuscript. Moscow. URL: http://www.hist1.narod.ru/ Science/Cycle/Cycle.html. *In Russian* (Нефедов С. А. Опыт имитационного моделирования демографического цикла. Рукопись (#54933), депонированная в ИНИОН РАН, М. URL: http://www.hist1.narod.ru/ Science/Cycle/Cycle.html).

*Nefedov S. A. 2000a. On Demographic Cycles in China's History (XVI–XIX Centuries).* Manuscript. Moscow. URL: http://www.hist1.narod.ru/ Science/China/China1.html. *In Russian* (Нефедов С. А. *О демографических циклах в истории Китая (XIV–XIX вв.).* Рукопись (#128367), депонированная в ИНИОН РАН, М. URL: http://www.hist1.narod.ru/ Science/China/China1.html).

*Nefedov S. A. 2000b.* On History Laws and Mathematical Models. *Izvestiya Uralskogo gosudarstvennogo universiteta* 15: 15–23. *In Russian* (Нефедов С. А. О законах истории и математических моделях. *Известия Уральского государственного университета* 15: 15–23).

*Nefedov S. A. 2001a.* Method of Demographic Cycles. *Uralski istoricheski vestnik* 7: 93–107. *In Russian* (Нефедов С. А. Метод демографических циклов. *Уральский исторический вестник* 7: 93–107).

*Nefedov S. A. 2001b*. *On Demographic Cycles in India's History.* Manuscript. Moscow. URL: http://www.hist1.narod.ru/Science/India/india.html. *In Russian* (Нефедов С. А. О демографических циклах в истории Индии. Рукопись (#556324), депонированная в ИНИОН РАН, М. URL: http://www.hist1.narod.ru/Science/ India/india.html).

*Nefedov S. A. 2002a.* An attempt of Modeling a Demographic Cycle. *Informatsionny byulleten assotsiatsii 'Istoriya I kompyuter'* 29: 131–142. *In Russian* (Нефе-дов С. А. Опыт моделирования демографического цикла. *Информационный бюллетень ассоциации 'История и компьютер'* 29: 131–142).

*Nefedov S. A. 2002b.* On the Theory of Demographic Cycles. *Ekonomicheskaya istoriya* 8: 116–121. *In Russian* (Нефедов С. А. О теории демографических циклов. *Экономическая история* 8: 116–121).

*Nefedov S. A. 2003.* The Theory of Demographic Cycles and Social Evolution of Ancient and Medieval Eastern Societies. *Vostok* 3: 5–22. *In Russian* (Нефедов С. А. Теория демографических циклов и социальная эволюция древних и средневековых обществ Востока. *Восток* 3: 5–22).

*Nefedov S. A. 2004.* A Model of Demographic Cycles in Traditional Societies: The Case of Ancient China. *Social Evolution & History* 3(1): 69–80.

*Nefedov S. A. 2005. Demographic-Structural Analysis of Socioeconomic History of Russia. The Late 15th – the Early 20th Centuries.* Ekaterinburg: Izdatelstvo UGGU. *In Russian* (Нефедов С. А. *Демографически-структурный анализ социально-экономической истории России. Конец XV – начало XX века*. Екатеринбург: Издательство УГГУ).

*Nefedov S. A. 2007. The Concept of Demographic Cycles.* Ekaterinburg: Izdatelstvo UGGU. *In Russian* (Нефедов С. А. *Концепция демографических циклов.* Екатеринбург: Издательство УГГУ).

*Nefedov S. A. 2008. The Factor Analysis of the Historical Process.* Moscow: Territoriya buduschego. *In Russian* (Нефедов С. А. *Факторный анализ исторического процесса.* М.: Территория будущего).

*Nefedov S. A. 2010.* On the Causes of the Russian Revolution. *On the Causes of the Russian Revolution* / ed. by L. E. Grinin, A. V. Korotayev, and S. Yu. Malkov, pp. 25–60. Moscow: LKI/URSS. *In Russian* (Нефедов С. А. О причинах Русской революции. *О причинах Русской революции* / Ред. Л. Е. Гринин, А. В. Коротаев, С. Ю. Малков, с. 25–60. М.: ЛКИ/URSS).

*Nefedov S. A., and Turchin P. V. 2007.* An Attempt of Modeling Demographic-Structural Cycles. *History and Mathematics: Macrohistorical Dynamics of the Society and State* / ed. by S. Yu. Malkov, L. E. Grinin, and A. V. Korotayev, pp. 153–167. Moscow: KomKniga/URSS. *In Russian* (Нефедов С. А., Турчин П. В. Опыт моделирования демографически-структурных циклов. *История и Математика: макроисторическая динамика общества и государства* / Ред. С. Ю. Малков, Л. Е. Гринин, А. В. Коротаев, с. 153–167. М.: КомКнига/URSS).

*Nelson R. R. 1956.* A Theory of the Low Level Equilibrium Trap in Underdeveloped Economies. *American Economic Review* 46: 894–908.

*Nepomnin O. E. 2005. History of China: Qing Epoch. The XVII – Early XX Centuries.* Moscow: Vostochnaya literatura. *In Russian* (Непомнин О. Е. *История Китая: Эпоха Цин. XVII – начало XX века*. М.: Восточная литература).

*Ototsky P. L. 2008. A Mathematical Model of the Regional Socio-Economic System Based on External Disturbance Effects.* PhD Dissertation (Physics and Mathematics). Moscow. *In Russian* (Отоцкий П. Л. *Математическая модель социально-экономической системы региона с учетом внешних возмущающих воздействий*: дис. ... канд. физ.-мат. наук. М.).

*Palmowski J. 1997. Dictionary of Twentieth Century World History*. Oxford: Oxford University Press.

*Panzac D. 1987.* The Population of Egypt in the Nineteenth Century. *Asian and African Studies* 21: 11–32.

*Perkins D. H. 1969. Agricultural Development in China 1368–1968.* Chicago, IL: Aldine.

*Project Ploughshares. 2008. Armed Conflicts Report*. URL: http://www.ploughshares. ca/ libraries/ ACRText/ACR-TitlePage.html.

*Rowe W. T. 2002.* Social Stability and Social Change. *The Cambridge History of China.* Vol. 9. Part 1. *The Ch'ing Empire to 1800* / Ed. by W. J. Peterson, pp. 473–562. Cambridge, UK: Cambridge University Press.

*Rummel R. J. 1994. Death by Government.* New Brunswick, NJ: Transaction Publishers.

*Sandstrom P., Sjöberg Ö. 1991. Albanian Economic Performance: Stagnation in the 1980s*. Soviet Studies 43(5): 931–947.

*Sarkees M. R. 1997.* The 'Correlates of War' Data on War: An Update to 1997. *Conflict Management and Peace Science* 18: 123–144.

*Small M., and Singer J. D. 1982. Resort to Arms: International and Civil Wars 1816–1980.* Beverly Hills, CA: Sage Publications.

*SPSS. 2010. World95 Database*. Chicago, IL: SPSS Inc.

*Steinmann G., and Komlos J. 1988*. Population Growth and Economic Development in the Very Long Run: A Simulation Model of Three Revolutions. *Mathematical Social Sciences* 16: 49–63.

*Steinmann G., Prskawetz A., and Feichtinger G. 1998.* A Model on the Escape from the Malthusian Trap. *Journal of Population Economics* 11: 535–550.

*Turchin P. 2003. Historical Dynamics: Why States Rise and Fall*. Princeton, NJ: Princeton University Press.

*Turchin P. 2005a.* Dynamical Feedbacks between Population Growth and Sociopolitical Instability in Agrarian States. *Structure and Dynamics* 1.

*Turchin P. 2005b. War and Peace and War: Life Cycles of Imperial Nations.* New York: Pi Press.

*Turchin P., and Korotayev A. 2006.* Population Density and Warfare: A Reconsideration. *Social Evolution & History* 5(2): 121–158.

*Turchin P., and Nefedov S. 2009. Secular Cycles.* Princeton, NJ: Princeton University Press.

*U.S. Bureau of the Census. 2010. World Population Information.* URL: http://www.census.gov/ipc/www/idb/worldpopinfo.php.

*Totten S. (Ed.) 1997. Century of Genocide: Eyewitness Accounts and Critical Views.* New York: Garland Publishing.

*Turchin P. V. 2007. Historical Dynamics. Towards Theoretical History.* Moscow: LKI/URSS. *In Russian* (Турчин П. В. *Историческая динамика. На пути к теоретической истории.* М.: ЛКИ/УРСС).

*United Nations. 2005. Statistic Division of the United Nations. Topic 3660, 'Nutrition, Minimum Energy Requirement, Kcal per Capita, per Day' (FAO/WHO Estimates)*. New York: UN.

*UN Population Division. 2010. United Nations. Department of Economic and Social Affairs. Population Division Database.* URL: http://www.un.org/esa/population.

*Usher D. 1989.* The Dynastic Cycle and the Stationary State. *The American Economic Review* 79: 1031–1044.

*Vasilyev A. M. (Ed.) 1990. The Arab Republic of Egypt.* Moscow: Nauka. *In Russian* (Васильев А. М. (Ред.) *Арабская Республика Египет*. М.: Наука).

*Vishnevski A. G. 1976. Demographic Revolution.* Moscow: Statistika. *In Russian* (Вишневский А. Г. *Демографическая революция*. М.: Статистика).

*Vishnevski A. G. 2005. Selected Works on Demography*. Vol. 1. *Demographic Theory and Demographic History.* Moscow: Nauka. *In Russian* (Вишневский А. Г.

*Избранные демографические труды*. Т. 1. *Демографическая теория и демографическая история*. М.: Наука).

*Wallechinsky D. 1995. Twentieth Century: History with the Boring Parts Left Out.* New York: Little Brown.

*Weinbaum M. G. 1985.* Egypt's 'Infitah' and the Politics of US Economic Assistance. 21(2): 206–222.

*White M. 2010a. Death Tolls for the Man-Made Megadeaths of the Twentieth Century*. URL: http://users.erols.com/mwhite28/warstatx.htm.

*White M. 2010b. Historical Atlas of the Twentieth Century*. URL: http://users.erols. com/mwhite28/20century.htm.

*Wiedl K. N. 2006. The Hama Massacre – Reasons, Supporters of the Rebellion, Consequences*. München: GRIN Verlag.

*Williams G. I. H. 2006. Liberia: The Heart of Darkness*. Victoria: Trafford Publishing.

*Wood J. W. 1998.* A Theory of Preindustrial Population Dynamics: Demography, Economy, and Well-Being in Malthusian Systems. *Current Anthropology* 39: 99–135.

*World Bank. 2014***.** *World Development Indicators Online.* Washington: World Bank, Electronic version. URL: http://data.worldbank.org/indicator.

*Zelin M. 2002.* The Yung-cheng Reign. *The Cambridge History of China.* Vol. 9. Part 1. *The Ch'ing Empire to 1800* / Ed. by W. J. Peterson, pp. 183–229. Cambridge, UK: Cambridge University Press.

*Zhao Wenlin and Xie Shujun-zhu. 1988. History of Chinese Population.* Peking: People's Publisher (in Chinese).

*Zinkina Yu. V. 2010.* Trends of Political-Demographic Dynamics and Perspectives of Maintenance of Political Stability in the Countries of Near and Middle East and East Africa in the Context of Structural-Demographic Theory. *Systemic Monitoring of Global and Regional Risks* / Ed. by D. A. Khaltourina, A. V. Korotayev, Yu. V. Zinkina, pp. 141–283. Moscow: Librokom/URSS. *In Russian* (Зинькина Ю. В. Тенденции политико-демографической динамики и перспективы сохранения политической стабильности в странах Ближнего и Среднего Востока и Восточной Африки с точки зрения структурно-демографической теории. *Системный мониторинг глобальных и региональных рисков* / Ред. Д. А. Халтурина, А. В. Коротаев, Ю. В. Зинькина, с. 141–283. М.: Либроком/URSS).