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Secular Cycles and Millennial Trends

Andrey Korotayev[1,2], Julia Zinkina[3], Alexey Andreev[4]
[1] *National Research University Higher School of Economics*
[2] *Institute of Oriental Studies, Russian Academy of Sciences*
[3] *The Russian Presidential Academy of National Economy and Public Administration*
[4] *Moscow State University*

Abstract

In the current paper, we investigate the relationship between secular cycles and millennial trends. The tests we perform suggest that the structure of millennial trends cannot be adequately understood without secular cycles being taken into consideration. At a certain level of analysis millennial trends turn out to be a virtual byproduct of demographic cycles that appear to incorporate certain trend-creating mechanisms. This suggests that demographic-political cycle models can serve as a basis for the development and testing of models accounting not only for secular cycles but also for millennial trends.

Introduction

We believe that one of the most important recent findings in the study of long-term dynamic social processes was the discovery of the sociodemographic cycles as a basic feature of complex agrarian systems' dynamics (see especially Nefedov 2003 and Turchin, Nefedov 2009 for an overview of the sociodemographic cycle theory). Secular cycles, according to Turchin, typically last between two and three centuries, and are driven by endogenous mechanisms that are internal to the state and society (Turchin 2008: 162).

The presence of demographic cycles in the pre-modern history of Europe and China has been known for quite a long time (e.g., Postan 1950, 1973; Abel 1974, 1980; Le Roy Ladurie 1974; Hodder 1978; Braudel 1973; Chao 1986; Cameron 1989; Goldstone 1991; Kul'pin 1990; Mugruzin 1994 etc.). Already in the 1980s rather sophisticated mathematical models of demographic cycles started to be produced (first for Chinese "dynastic cycles") (Usher 1989). By now, a considerable number of such models have been developed (Chu and Lee 1994; Malkov and Sergeev 2001, 2002; Malkov *et al.* 2002; Malkov 2002; Turchin 2003, 2005; Nefedov 2002; 2004; 2013; Turchin, Korotayev 2006; Turchin, Nefedov

Corresponding author's e-mail: akorotayev@gmail.com

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2009; Korotayev, Khaltourina 2006; Korotayev, Malkov, and Khaltourina 2006; Korotayev et al. 2011; Korotayev, Malkov, Grinin 2014).[1] In the present article we will discuss the interaction between cyclical dynamics described by such models and millennial trends (for the notion of millennial trends see, e.g., Korotayev, Malkov, and Khaltourina 2006).

Hypotheses

As is well known, variables such as the carrying capacity of land, cultural complexity, and empire sizes are not constant, but rather experience long-term trend dynamics in their rise, and there are grounds to maintain that those long-term ("millennial") trends are connected with secular cycles in a rather tight way.

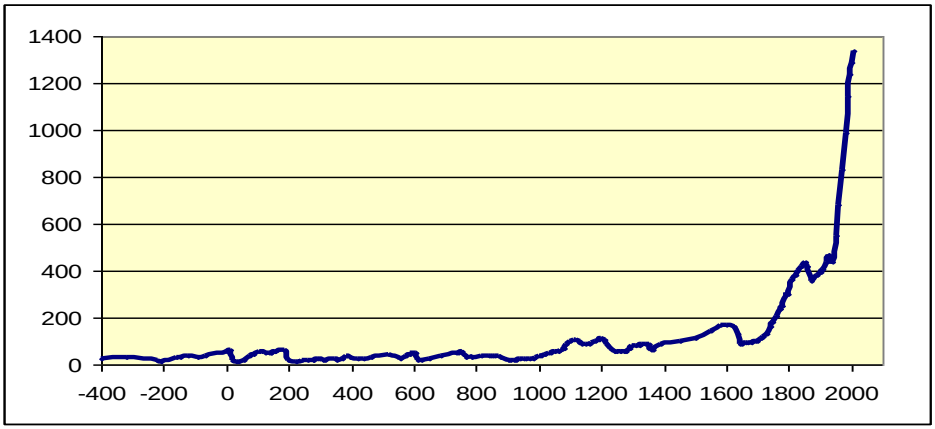
For example, there are both theoretical and empirical grounds to maintain that carrying capacity not only experienced an upward long-term trend (such as may be inferred, e.g., from Figure 1), but also that innovations contributing to this trend occurred during particular phases of demographic-political cycles.

While resources are relatively abundant in the initial upward growth phases of agrarian states, incentives to create innovations leading to the rise of carrying capacity are commonly insufficient. These phases, however, were also very important, as during their presence strong incentives arose for innovations leading to the rise of labor productivity. Rather, quite in accordance with Boserup's (1965) argument, innovations raising the carrying capacity of land tended to occur during the intermediate growth phase preceding a demographic collapse. While until a demographic revolution these innovations usually acted only to delay demographic collapses, they still secured the existence of a very important upward trend, which to some extent could be accounted for as a by-product of the demographic cycles.

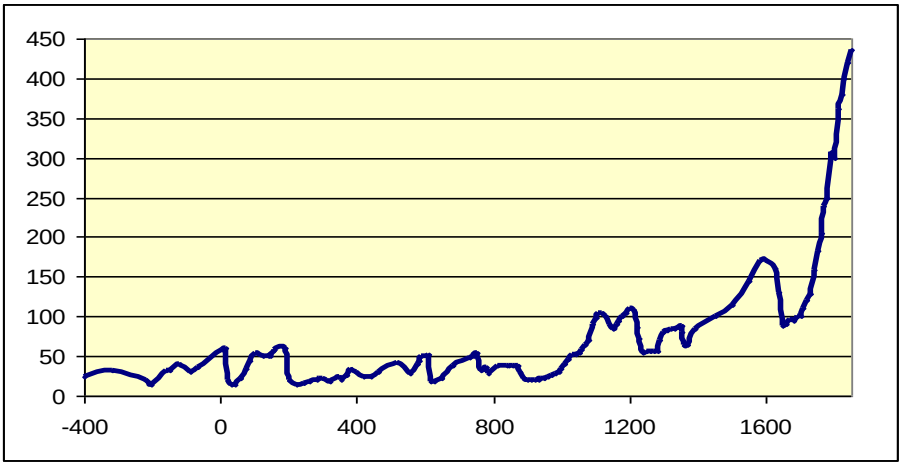
Another trend is the one toward the growth of polity sizes (see Figures 2 and 3 for West and East Asia).

This trend appears to be accounted for by the fact that infrastructure created by empires do not usually disappear entirely with the collapse of their creators. Hence, new empires can rely to a considerable extent on preexisting infrastructure and, therefore, do not have to build imperial infrastructure entirely anew, which makes it more likely for later empires to overgrow the size of earlier ones.

[1] There are also a rather large number of mathematical models designed to account for the escape from Malthusian Trap and its sociopolitical consequences, rather than for the structure of pre-industrial population cycles (Artzrouni and Komlos 1985; Steinmann and Komlos 1988; Komlos and Artzrouni 1990; Steinmann, Prskawetz, and Feichtinger 1998; Wood 1998; Kögel and Prskawetz 2001; Komlos and Nefedov 2002; Korotayev et al. 2011; Korotayev, Malkov, Grinin 2014; Zinkina, Korotayev 2014a, 2014b; Zinkina, Malkov, Korotayev 2014; Korotayev, Zinkina 2014).



a) 400 BCE–2005 CE



b) 400 BCE–1850 CE. NOTE: the diagram reproduces estimates surveyed by Korotayev, Malkov, and Khaltourina (2006a: 47–88)

Figure 1. Trend to the growth of population (in millions) in China.

What could be our theoretical expectations for the relationship between phases of these cycles? It turns out that a considerable number of relevant theoretical predictions can be generated by Turchin's demographic-fiscal model (Turchin 2003: 121–127; 2008: 162–166), building on Goldstone (1991). The main logic of

this model can be outlined as follows:

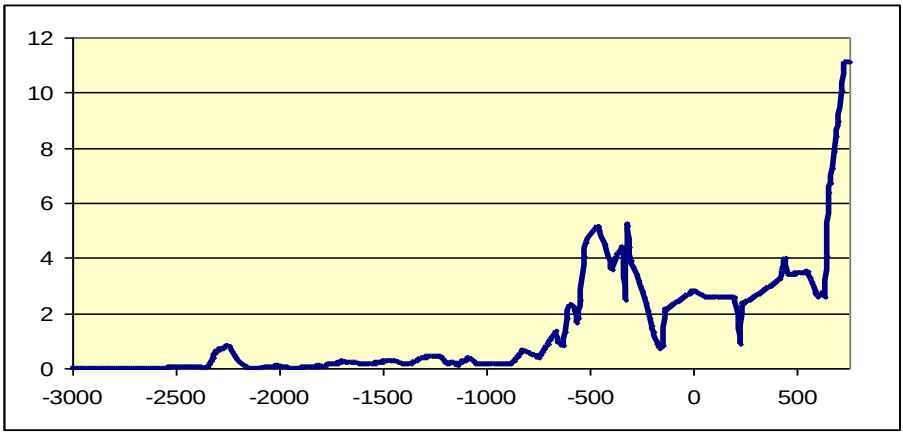


Figure 2. Trend in the growth of the largest state/empire territory size (millions of square km) in West Asian/Mesopotamia centered system, 3000 BCE–750 CE (Taagepera 1968; 1978a; 1978b; 1979; 1997).

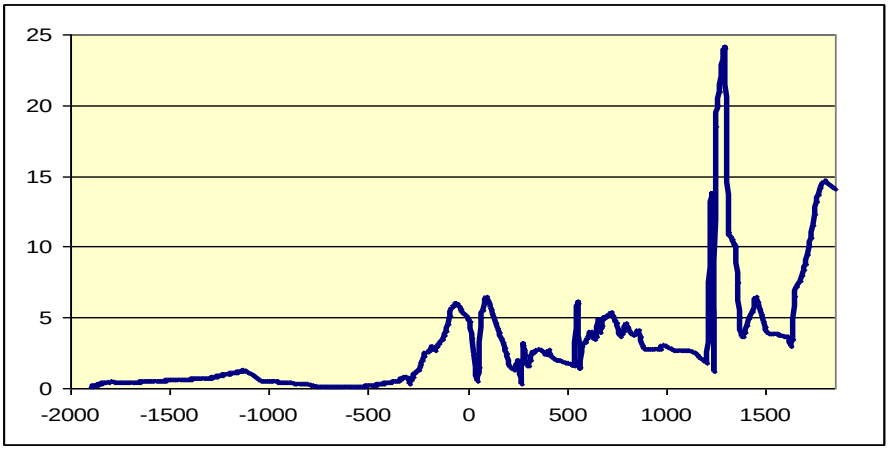


Figure 3. Trend in the growth of the largest state/empire territory size (millions of square km) in East Asian/China centered system, 1900 BCE–1850 CE (Taagepera 1968; 1978a; 1978b; 1979; 1997; Chase-Dunn 2016).

During the initial phase of a demographic cycle we observe relatively high levels of per capita production and consumption, which leads not only to relatively high population growth rates, but also to relatively high rates of surplus production. As a result, during this phase the population can afford to pay taxes without great

problems, the taxes are quite easily collected, and population growth is accompanied by the growth of state revenues. During the intermediate phase, increasing overpopulation leads to the decrease of per capita production and consumption levels, it becomes more and more difficult to collect taxes, and state revenues stop growing, whereas the state expenditures grow due to the growth of the population controlled by the state. As a result, during this phase the state starts experiencing considerable fiscal problems. During the final pre-collapse phases overpopulation leads to further decrease of per capita production, surplus production further decreases, and state revenues shrink, whereas the state needs more and more resources to control the growing, though at lower and lower rates, population. Eventually this leads to state breakdown and demographic collapse, after which a new demographic cycle begins—until the escape from the Malthusian Trap that was started by the advanced economies in Europe and North America in the early 19th century, and that was followed by the overwhelming majority of the social systems afterwards—with a partial exception of Tropical Africa (see, e.g., Kögel, Prskawetz 2001; Zinkina, Korotayev 2014a; Korotayev, Zinkina 2015; Grinin, Korotayev 2015; Korotayev et al. 2016).

What kind of territorial expansion/contraction pattern could be generated by such demographic-fiscal dynamics? During the initial phase state revenues are high and continue to grow, which makes it possible for a state to support large armies, and to undertake active territorial expansion. Note that this is only valid for unipolar regional systems, i.e., with a single strong state. In multipolar regional systems comprising a few equally strong states we can only expect that the composite states will try to undertake attempts for territorial expansion. However, there are naturally no guaranties that such attempts of any particular state will be successful. What is more, within a fairly balanced multipolar system such attempts undertaken by a few states could result in a stalemate, as a result of which none of the participant states would have considerable territorial gains.

During the intermediate phase the state starts experiencing fiscal problems, and its ability to support large and effective armies decreases. Thus, we have grounds to expect that during this phase imperial territorial expansion will slow down.

During the final pre-collapse phase state revenues considerably decrease, which leads to a considerable decrease of the size and effectiveness of the military forces supported by the state. Hence, we have grounds to expect that during this phase imperial territorial expansion should stop. What is more, during this phase state territory is likely to start contracting (note that a similar set of hypotheses has been produced by Turchin using a somewhat different logic [Turchin 2008]).

Methods

To test these predictions we use Taagepera's database on the historical dynamics of empire sizes (Taagepera 1968; 1978a; 1978b; 1979; 1997), as well as Nefedov's (2003; 2005) data on population and consumption dynamics.[2] Note that in his seminal article Nefedov provides population and consumption dynamics estimates with respect to the following secular cycles within unipolar regional systems: the Babylonian Cycle (the 7th and 6th centuries BCE), the Eastern Han Cycle (the 1st and 2nd centuries CE), the Ming Cycle (the 14th–17th centuries CE), the Mughal Cycle (the 16th and 17th centuries CE), the Qing Cycle (the 18th and 19th centuries), the Roman Principate Cycle (the 1st century BCE–the 2nd century CE), the Song Cycle (the 10th and 11th centuries CE), the Early Tang Cycle (the 7th and 8th centuries CE), the Western Han Cycle (the 2nd and 1st centuries BCE). It is important to note that the above-mentioned publications by Taagepera provide the necessary data on empire size dynamics for all the abovementioned secular cycles.

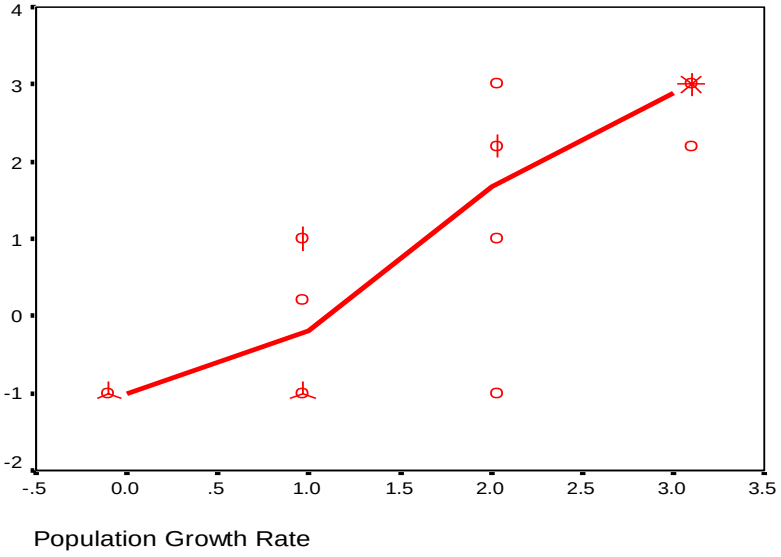


Figure 4. The effect of population growth rate on territorial expansion/aggressive external warfare (scatterplot with fitted LOWESS line). NOTE: note that both axes are purely ordinal (not interval), for detail see Table S1.

[2] Note that in both cases we are not really dealing with samples, but rather with the general populations of all the cases, for which empirical estimates are available.

Tests

We first test the least counter-intuitive prediction. This is that the phases of relatively rapid population growth should correlate with phases of relatively rapid territorial expansion.

The test supports this hypothesis: the correlation has turned out to be in the predicted direction, very strong and statistically significant (see Figure 4 and Table S1).

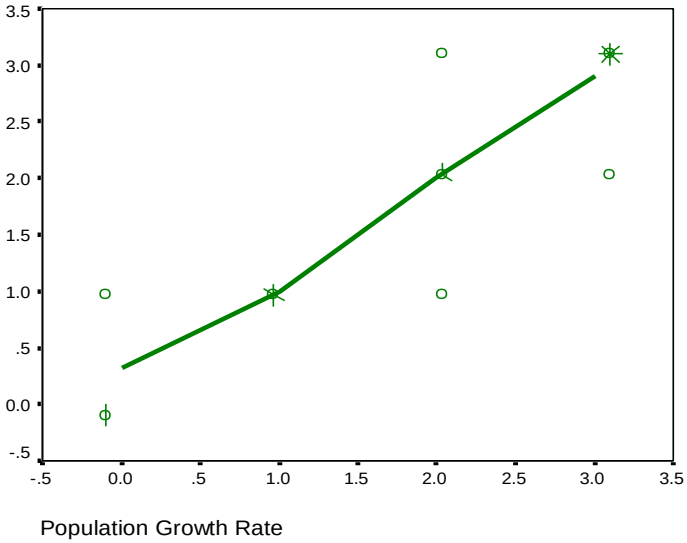


Figure 5. The effect of population growth rate on relative consumption rate (scatterplot with fitted LOWESS line). NOTE: note that both axes are purely ordinal (not interval), for detail see Table S2.

Note, however, that for the direct test of this hypothesis we had to rely almost exclusively on the Chinese data as East Asia is the only region (and the only unipolar region) for which we have direct data on historical population dynamics. Note that even the Roman Empire cannot be treated as an exception. Indeed, we have a lot of indirect evidence on the population size of the Early Roman Empire (till the 3rd century CE, see, e.g., Turchin and Nefedov 2009: 211–239; Koepke 2016), but even for the Early Roman Empire we only have direct census evidence for the number of Roman citizens who only constituted a minority of the Empire population—unlike for China where for the most of the period between 2 CE and 1851 CE we have quite systematic census data on the size of Chinese tax-paying population who encompassed the overwhelming majority of the overall

population of the Chinese empires (see, e.g., Durand 1960, 1977; Bielenstein 1987; Korotayev, Malkov, Khaltourina 2006; Korotayev 2012).

On the other hand, it has turned out to be possible to collect a sufficient amount of extra-Chinese cases to test our next hypothesis, the one between relative per capita consumption levels and territorial expansion/contraction. What are our theoretical predictions in this case?

To start with, the demographic cycle models predict that relatively fast population growth should correlate with relatively high consumption levels. Our empirical test of this assumption confirms its validity (see Figure 5 and Table S2).

The test supports this hypothesis: the correlation turns out to be in the predicted direction, very strong and statistically significant (see Figure 6 and Table S3).

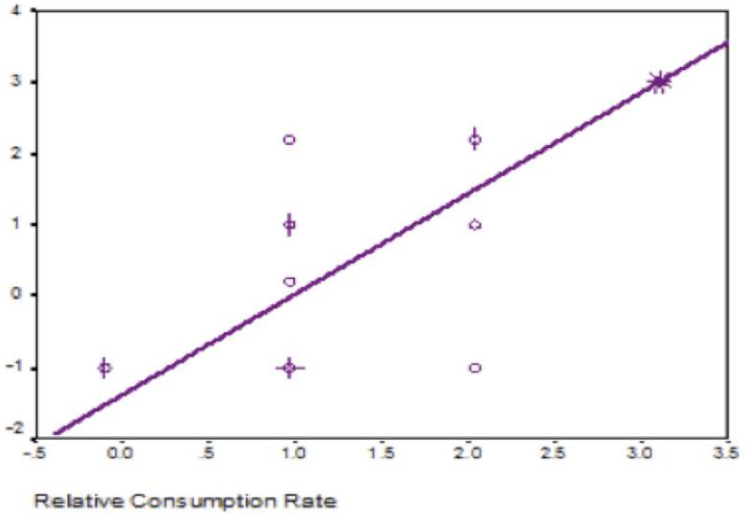
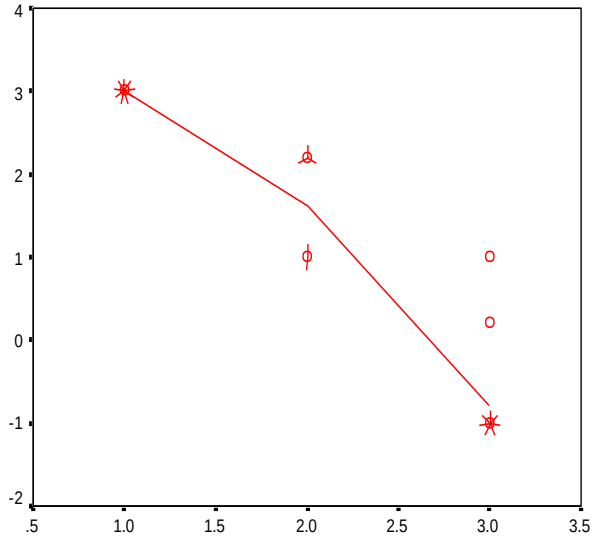


Figure 6. The effect of relative consumption rate on territorial expansion/aggressive external warfare.

The population of the core area[3] is the smallest during the initial phase of a demographic cycle and is the highest during the final pre-collapse phase. This results in one more counter-intuitive hypothesis—the higher the population of the empire core area, the lower its expansion rate. Our empirical test supports this hypothesis too (see Figure 7 and Table S4).

[3] The core area is defined here as the area of the central polity of a unipolar region before the start of its expansion at the beginning of a political-demographic cycle.



1 – low in comparison with other phases of respective cycle
2 – intermediate in comparison with other phases of respective cycle
3 – high in comparison with other phases of respective cycle

Figure 7. The effect of core area population on territorial expansion/aggressive external warfare.

Conclusion

The importance of these findings is to suggest that the structure of millennial trends cannot be adequately understood without secular cycles being taken into consideration. At a certain level of analysis millennial trends turn out to be a virtual byproduct of demographic cycles that appear to incorporate certain trend-creating mechanisms. This suggests that demographic-political cycle models can serve as a basis for the development and testing of models accounting not only for secular cycles but also for millennial trends (see Korotayev, Malkov, Khaltourina 2006; Korotayev, Khaltourina 2006; Korotayev 2007 for some more detail).

References

Abel, W. 1974. *Massenarmut und Hungerkrisen im vorindustriellen Europa. Versuch einer Synopsis*. Hamburg: Parey.

Abel, W. 1980. *Agricultural Fluctuations in Europe from the Thirteenth to the Twentieth Centuries*. New York, NY: St. Martin's. doi: 10.4324/97813150190 93.

Artzrouni, M., and J. Komlos. 1985. "Population Growth through History and the Escape from Malthusian Trap: A Homeostatic Simulation Model." *Genus* 41:21–39. http://www.jstor.org/stable/29788455.

Bielenstein, H. 1987. "Chinese Historical Demography A.D. 2 to 1982." *Bulletin of the Museum of Far Eastern Antiquities* 59: 1–288.

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

Boserup, E. 1965. *The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure.* Chicago, IL: Aldine.

Cameron, R. 1989. *A Concise Economic History of World.* New York, NY: Oxford University Press.

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

Chase-Dunn, C. 2016. *Polities and Settlements Research Working Group Database.* Riverside, CA: UCR. http://www.irows.ucr.edu/.

Chu, C. Y. C., and R. D. Lee. 1994. "Famine, Revolt, and the Dynastic Cycle: Population Dynamics in Historic China." *Journal of Population Economics* 7:351–78. http://link.springer.com/article/10.1007/BF00161472. doi: 10.1007/bf00161472.

Durand, J. D. 1960. "The Population Statistics of China, A.D. 2–1953." *Population Studies* 13: 209–56. doi: 10.2307/2172247.

Durand, J. D. 1977. "Historical Estimates of World Population: An Evaluation." *Population and Development Review* 3(3): 255–96. doi: 10.2307/1971891.

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

Grinin L., Korotayev A. 2015. *Great Divergence and Great Convergence. A Global Perspective.* New York, NY: Springer. doi: 10.1007/978-3-319-17780-9.

Hodder, I. 1978. "Simulation in Population Studies." In *Simulation Studies in Archeology*, edited by I. Hodder, 59–63. Cambridge, UK: Cambridge University Press.

Kögel, T., and A. Prskawetz. 2001. "Agricultural Productivity Growth and Escape from the Malthusian Trap." *Journal of Economic Growth* 6:337–57. http://link.springer.com/article/10.1023/A:1012742531003. doi: 10.1023/a:1012742531003.

Koepke, N. 2016. "The Biological Standard of Living in Europe from the Late Iron Age to the Little Ice Age." In *The Oxford Handbook of Economics and Human Biology*, edited by J. Komlos and I. Kelly, 77–108. Oxford: Oxford University Press. doi: 10.1093/oxfordhb/9780199389292.013.34.

Komlos, J., and S. Nefedov. 2002. "A Compact Macromodel of Pre-Industrial Population Growth." *Historical Methods* 35:92–4. doi: 10.1080/0615440209604133.

Komlos, J. and M. Artzrouni. 1990. "Mathematical Investigations of the Escape from the Malthusian Trap." Mathematical Population Studies 2:269–87. doi: 10.1080/08898489009525313.

Korotayev, A. V. 2007. "Secular cycles and millennial trends: A mathematical model." In *Mathematical modeling of social and economic dynamics*, edited by M. G. Dmitriev, A. P. Petrov, and N. P. Tretyakov, 118–125. Moscow: RUDN.

Korotayev A. 2012. "Globalization and mathematical modeling of global development." *Globalistics and Globalization Studies* 1: 148–158. http://www.sociostudies.org/almanac/articles/globalization_and_mathematical_modeling_of_global_development/.

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

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

Korotayev, A. V., S.Y. Malkov, and L.E. Grinin. 2014. "A Trap at the Escape from the Trap? Some Demographic Structural Factors of Political Instability in Modernizing Social Systems." *History and Mathematics* 4:201–267.

Korotayev, A., and J. Zinkina. 2014. "How to Optimize Fertility and Prevent Humanitarian Catastrophes in Tropical Africa." *African Studies in Russia* 6: 94–107.

Korotayev, A., and J. Zinkina. 2015. "East Africa in the Malthusian Trap?" *Journal of Developing Societies* 31(3): 1–36. doi: 10.1177/0169796x15590322.

Korotayev A., J. Zinkina, J. Goldstone, and S. Shulgin. 2016. "Explaining Current Fertility Dynamics in Tropical Africa From an Anthropological Perspective: A Cross-Cultural Investigation." *Cross-Cultural Research* 50 (3), 251–280. doi: 10.1177/1069397116644158.

Korotayev, A., J. Zinkina, S. Kobzeva, J. Bozhevolnov, D. Khaltourina, A. Malkov, and S. Malkov. 2011. "Demographic-structural factors of political instability in modern Africa and West Asia." *Cliodynamics* 2(2): 276–303. http://escholarship.org/uc/item/79t737gt.

Kul'pin, E. S. 1990. *People and Nature in China*. Moscow: Nauka (in Russian).

Le Roy Ladurie, E. 1977. *The Peasants of Languedoc*. Urbana, IL: University of Illinois Press.

Malkov, S. Y. 2002. "Mathematical Modeling of Historical Processes." In *Novoe v sinergetike: Vzgljad v tret'e tysjacheletie*, edited by G. G. Malinetskij and S. P. Kurdjumov, 291–323. Moscow: Nauka (in Russian).

Malkov, S. Y., and A. V. Sergeev. 2001. "Model of Economic-Demographic Processes in Agrarian Society." *Matematika. Komp'juter. Obrazovanie* 9: 267 (in Russian).

Malkov, S. Yu., and A. V. Sergeev. 2002. "Mathematical Modeling of Socio-Economic Stability of a Developing Society." *Strategicheskaja stabil'nost'* 4:54–61 (in Russian).

Malkov, S. Yu., Yu. V. Kosse, V. N. Bakulin, and A. V. Sergeev. 2002. "Socio-Economic and Demographic Dynamics in Agrarian Societies." *Matematicheskoe modelirovanie* 14(9):103–8 (in Russian).

Mugruzin, A. S. 1994. *Agrarian and Peasant Problems of China*. Moscow: Nauka (in Russian).

Nefedov, S. A. 2002. "Mathematic Modeling of Demographic Cycle." *Istorija i komp'juter* 29:131–42 (in Russian).

Nefedov, S. A. 2002b. "On the Theory of Demographic Cycles." *Ekonomicheskaya Istoriya* 8:116–121 (In Russian).

Nefedov, S. A. 2003. "Theory of Demographic Cycles and Social Evolution of the Ancient and Medieval Societies of the East." *Vostok* 3:5–22 (in Russian, for its translation into English see Nefedov 2005).

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. "A Theory of Demographic Cycles and the Social Evolution of Ancient and Medieval Oriental Societies." Irvine, CA: UC Irvine Social Dynamics and Complexity Working Papers Series, 4.

Nefedov, S. A. 2013. "Modeling Malthusian Dynamics in Pre-industrial Societies." *Cliodynamics* 4(2): 229–240. http://escholarship.org/uc/item/71g00580.

Postan, M. M. 1973. *Essays on Medieval Agriculture and General Problems of the Medieval Economy*. Cambridge: Cambridge University Press. doi: 10.1017/cbo9780511896729.

Postan, M. M. 1950. "Same Economic Evidence of Declining Population in the Later Middle Ages." *Economic History Review.* 2nd ser. 2:130–67. doi: 10.2307/2590120.

Steinmann, G., and J. Komlos. 1998. "Population Growth and Economic Development in the Very Long Run: A Simulation Model of Three Revolutions." *Mathematical Social Sciences* 16:49–63. http://www.sciencedirect.com/science/article/pii/0165489688900042. doi: 10.1016/0165-4896(88)90004-2.

Steinmann, G., A. Prskawetz, and G. Feichtinger 1998. "A Model on the Escape from the Malthusian Trap." *Journal of Population Economics* 11: 535–50. http://link.springer.com/article/10.1007%2Fs001480050083. doi: 10.1007/s001480050083.

Taagepera, R. 1968. "Growth Curves of Empires." *General Systems* 13:171–175.

Taagepera, R. 1978a. "Size and Duration of Empires: Systematics of Size." *Social Science Research* 7:108–127. doi: 10.1016/0049-089x(78)90007-8.

Taagepera, R. 1978b. "Size and Duration of Empires: Growth-Decline Curves, 3000 to 600 B.C." *Social Science Research* 7:180–196. doi: 10.1016/0049-089x(78)90010-8.

Taagepera, R. 1979. "Size and Duration of Empires: Growth-Decline Curves, 600 B.C. to 600 A.D." *Social Science History* 3:115–138. doi: 10.2307/1170959.

Taagepera, R. 1997. "Expansion and Contraction Patterns of Large Polities: Context for Russia." *International Studies Quarterly* 41:475–504. doi: 10.1111/0020-8833.00053.

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

Turchin, P. 2005. "Dynamical Feedbacks between Population Growth and Sociopolitical Instability in Agrarian States." *Structure and Dynamics* 1. http://escholarship.org/uc/item/0d17g8g9.

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

Turchin, P., and S. Nefedov. 2009. *Secular Cycles*. Princeton, NJ: Princeton University Press. doi: 10.1515/9781400830688.

Usher, D. 1989. "The Dynastic Cycle and the Stationary State." *The American Economic Review* 79:1031–1044. http://www.jstor.org/stable/1831435?=?seq=1#page_scan_tab_contents.

Zinkina, J., and A. Korotayev. 2014a. "Explosive Population Growth in Tropical Africa: Crucial Omission in Development Forecasts (Emerging Risks and Way out)." *World Futures* 70(4): 271–305. doi: 10.1080/02604027.2014.894868.

Zinkina, J., and A. Korotayev. 2014b. "Projecting Mozambique's Demographic Futures." *Journal of Futures Studies* 19(2): 21–40.

Zinkina, J., A. Malkov, and A. Korotayev. 2014. "A mathematical model of technological, economic, demographic and social interaction between the center and periphery of the World System." In *Socio-economic and technological innovations: Mechanisms and institutions*, edited by K. Mandal, N. Asheulova, and S.G. Kirdina, 135–147. New Delhi: Narosa Publishing House.