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**Abstract:**

In the current paper we investigate the relation between secular cycles and millennial trends. The tests we have performed 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 the demographic cycle mechanisms, which turn out to incorporate certain trend-creating mechanisms. Demographic-political cycle models can serve as a basis for the development and testing of models accounting not only for cycles but also for secular trends. In order to do this, we suggest to alter the basic assumptions of the earlier generations of demographic cycle models (that both the carrying capacity of land and the polity size are constant). The variables such as carrying capacity of land, cultural complexity, and empire sizes are actually not constant, but rather experience long-term trend dynamics in the rise, and the new generation of models needs to account for this fact.

**Supporting material:**

Korotayev et al. Supplemental Information

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## **Secular Cycles and Millennial Trends**

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### **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

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2009; Korotayev, Khaltourina 2006; Korotayev, Malkov, and Khaltourina 2006; Korotayev et al. 2011; Korotayev, Malkov, Grinin 2014).<sup>1</sup> 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.

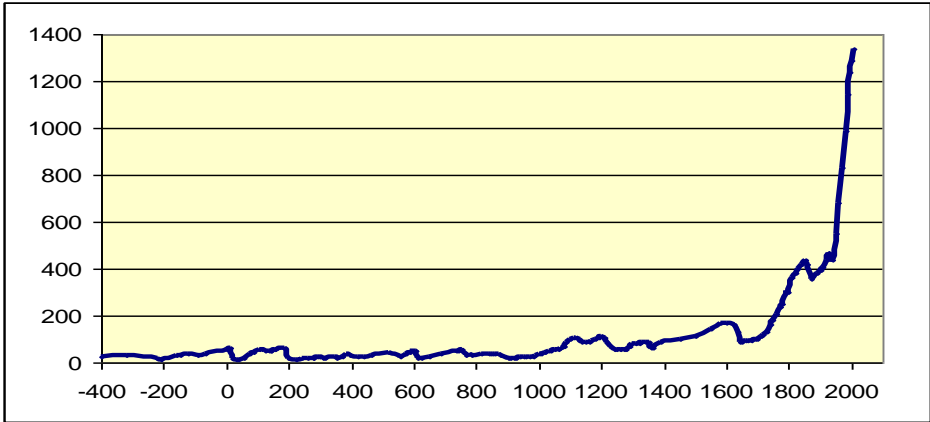
While resources are relatively abundant in the initial upward growth phases of agrarian states, incentives to create innovations leading to the rise of carrying capacity are commonly insufficient. These phases, however, were also very important, as during their presence strong incentives arose for innovations 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).

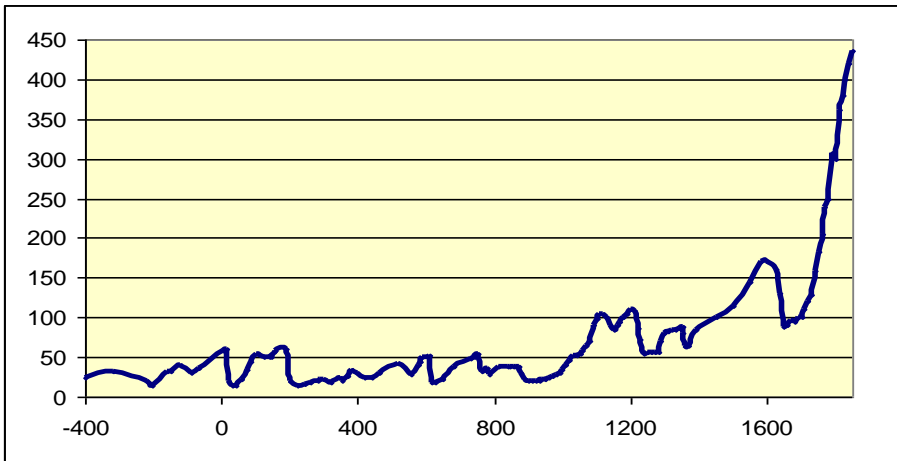
This trend appears to be accounted for by the fact that infrastructure created by empires do not usually disappear entirely with the collapse of their creators. Hence, new empires can rely to a considerable extent on preexisting infrastructure and, therefore, do not have to build imperial infrastructure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

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<sup>1</sup> 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

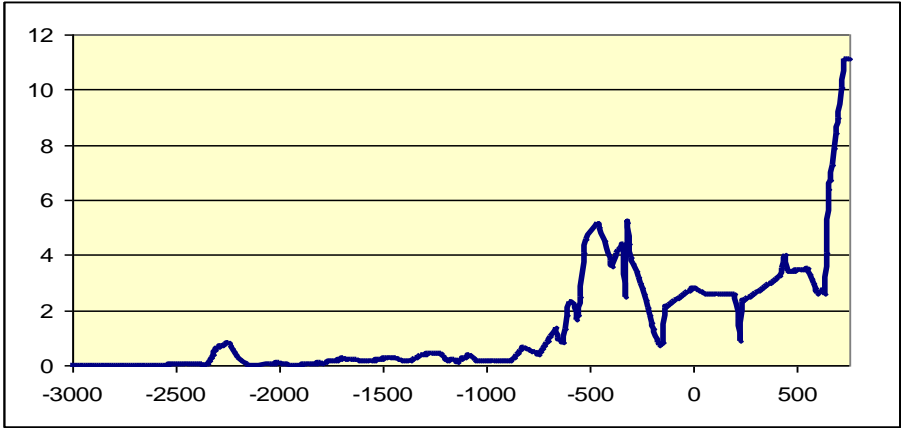


b) 400 BCE–1850 CE. NOTE: the diagram reproduces estimates surveyed by Korotayev, Malkov, and Khalitourina (2006a: 47–88)

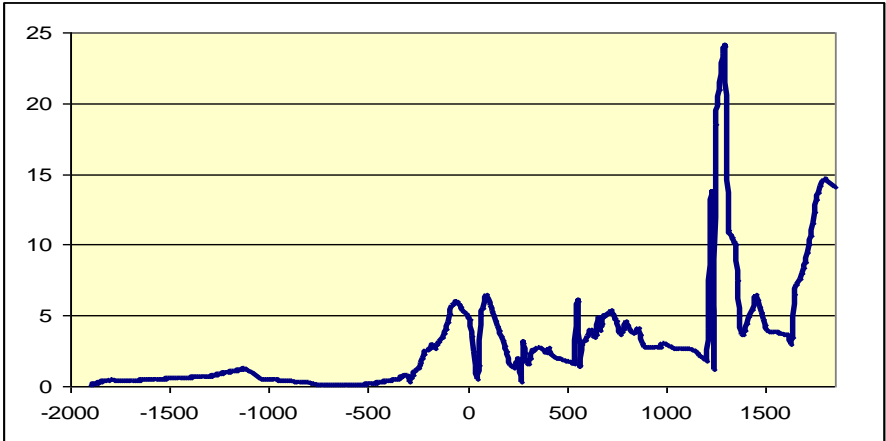
**Figure 1.** Trend to the growth of population (in millions) in China.

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 19<sup>th</sup> 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).

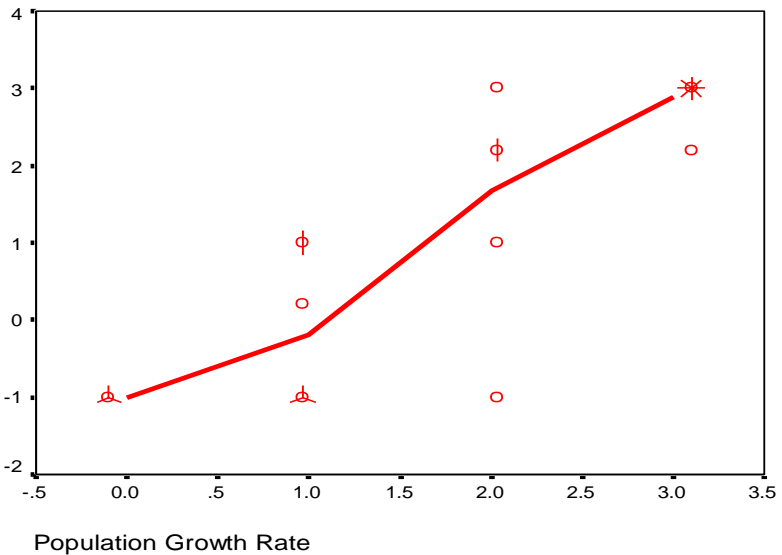
What kind of territorial expansion/contraction pattern could be generated by such demographic-fiscal dynamics? During the initial phase state revenues are high and continue to grow, which makes it possible for a state to support large armies, and to undertake active territorial expansion. Note that this 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.<sup>2</sup> 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 7<sup>th</sup> and 6<sup>th</sup> centuries BCE), the Eastern Han Cycle (the 1<sup>st</sup> and 2<sup>nd</sup> centuries CE), the Ming Cycle (the 14<sup>th</sup>–17<sup>th</sup> centuries CE), the Mughal Cycle (the 16<sup>th</sup> and 17<sup>th</sup> centuries CE), the Qing Cycle (the 18<sup>th</sup> and 19<sup>th</sup> centuries), the Roman Principate Cycle (the 1<sup>st</sup> century BCE–the 2<sup>nd</sup> century CE), the Song Cycle (the 10<sup>th</sup> and 11<sup>th</sup> centuries CE), the Early Tang Cycle (the 7<sup>th</sup> and 8<sup>th</sup> centuries CE), the Western Han Cycle (the 2<sup>nd</sup> and 1<sup>st</sup> 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.

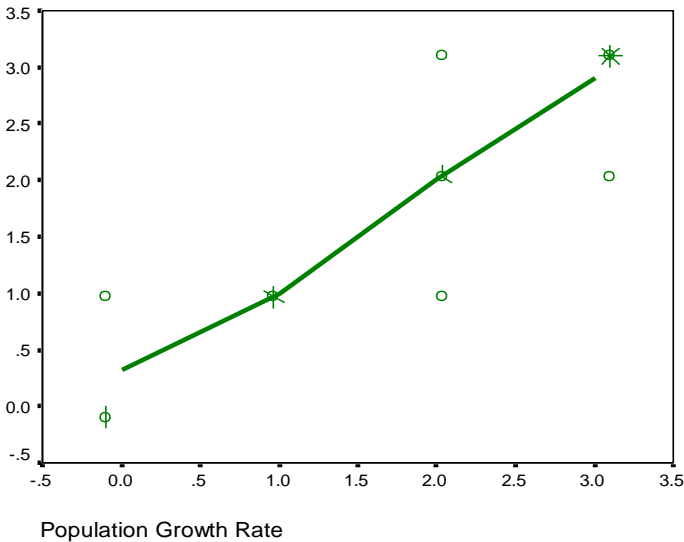
<sup>2</sup> Note that in both cases we are not really dealing with samples, but rather with the general populations of all the cases, for which empirical estimates are available.



## 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.

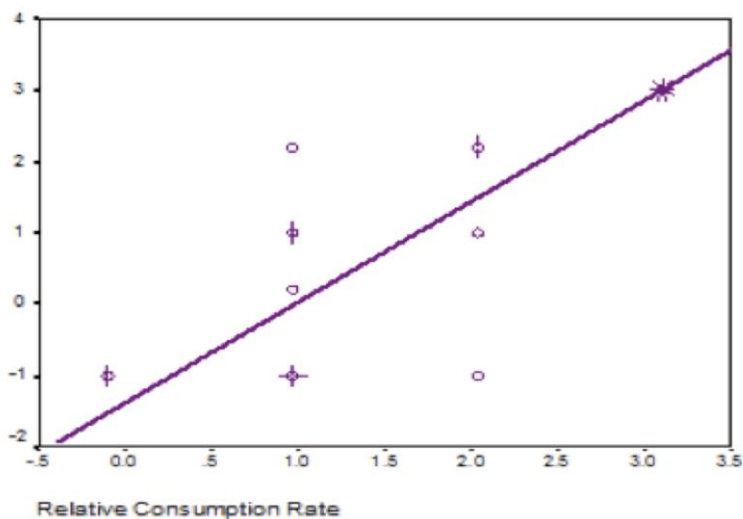
Note, however, that for the direct test of this hypothesis we had to rely almost exclusively on the Chinese data as East Asia is the only region (and the only unipolar region) for which we have direct data on historical population dynamics. Note that even the Roman Empire cannot be treated as an exception. 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).

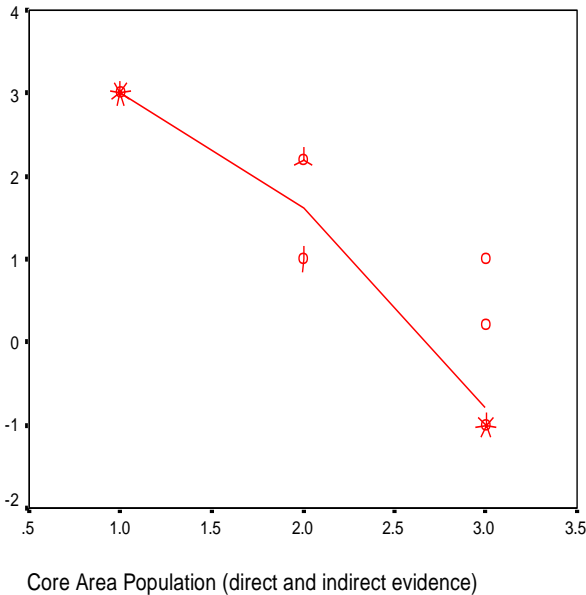


**Figure 6.** The effect of relative consumption rate on territorial expansion/aggressive external warfare.

The population of the core area<sup>3</sup> 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).

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<sup>3</sup> 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).

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