TURCHIN CYCLES AND LONG K-WAVES

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Abstract

The text presents the modelling of history using cliodynamics according to P. Turchin. Cliodynamics is a new scientific discipline at the interface of historical macrosociology, cliometrics and mathematical modelling of social processes. Scientific regularities are sought to be the basis of history, including the so-called iron law of social development. For example, quantitative historical analysis is intended to reveal that complex human societies are affected by recurrent and predictable waves of political instability. Turchin contributes to the mathematical modelling of secular (long-term) cycles, primarily sociodemographic cycles. By modelling the dynamics of systems, they are supposed to demonstrate that these cycles were a fundamental characteristic of complex agrarian systems. In doing so, both trend and cyclical components are traceable in the historical dynamics, including interactions or connections with the theory (and practice) of economic long K-waves. Including the limits of these approaches. According to Turchin, cyclical development is related to humans' genetic makeup or the succession of generations. The article is an original scientific essay that uses data from both historical sources and available scientific literature. To achieve the stated goal, descriptive, comparative, and qualitative analysis methods were used.

Key words: Turchin Cycles, Long K-waves, cliodynamics, sociodemographic secular cycles

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Introduction

Turchin is one of the co-founders of cliodynamics, i.e. a mathematical modelling and statistical analysis of the dynamics of historical societies. A new scientific discipline on the border between historical macrosociology, cliometrics and mathematical modelling of social processes. Scientific laws that are supposed to be the basis of history are sought, including the so-called iron law of social development. Quantitative historical analysis is supposed to reveal, for example, that recurring and predictable waves of political instability influence complex human societies. (Turchin, 2010) predicted a period of unrest in the USA around 2020. The book (Turchin, 2024) models the built-in mechanisms of self-destruction of civilisations of the

era of cities and states, based on complex mathematics and data on prosperity. The key drivers of social and political instability are supposed to be wealth inequality, general impoverishment, and overproduction by elites.

The theory of pre-industrial empires is based (Turchin, 2005) on social cooperation. Societies that create a high degree of cooperation and adequate social capital should prosper and expand. Turchin contributes to the mathematical modelling of secular (long-term) cycles. In the sense of cycles, primarily sociodemographic. By modelling the dynamics of systems, they demonstrate that these cycles should have been the basic characteristic of complex agrarian systems. Moreover, both trend and cyclical components, including interactions, should be traceable in historical dynamics.

Gradually, Turchin arrived at the approximately 50-year cycle 1870-1920-1970-2020, which he elaborates on in several books. Very long "secular cycles" are supposed to interact with shorter-term processes, including cyclical ones. In the USA, around 1870, 1920 and 1970, instability should increase every half a century so that another increase could occur around 2020, which should correspond to the decline of the long K-wave, following 40-60-year growth economic cycles. The result of synchronisation is supposed to be the severity of the future recession.

1 Seductively misleading cliodynamics

Peter Valentinovich Turchin is a Russian-American scientist, born in the USSR in 1957. His research focuses on the complexities of historical social science, with research targeting social and cultural evolution, economic history, cliometrics, and mathematical modelling of long-term social processes. He studied biology in Moscow, and in 1977, his father-in-law and his family were expelled. He earned academic degrees in biology and zoology in the USA. He founded *Cliodynamics: The Journal of Quantitative History and Cultural Evolution,* maintains the *Cliodynamica* blog, and founded the *Seshat* historical database. He is a professor emeritus of evolutionary biology at the University of Connecticut, director of the *Social Complexity and Collapse* project at the Complexity Science Hub in Vienna, and research fellow at the School of Anthropology, University of Oxford.

Turchin is originally an ecologist. He has tried to apply mathematical theories and statistical modelling to different types of ecosystems.[1] He finds a relationship between the size

[1] The population cycles of rodents in Finland, Sweden and Norway are modelled in the text (Turchin & Hanski, 2001).

and structure of populations and the ability to reproduce. In the right environment, populations grow, but at some point, the pressure on resources will precipitate a catastrophic decline. The decline again changes the balance and allows for a new phase of growth and expansion, so that the life cycle of all living things is discernible and traceable (though not necessarily predictable). Knowledge begins to be applied to man and the history of civilisations. He becomes a co-founder of cliodynamics - the mathematical modelling and statistical analysis of the dynamics of historical societies. It is a new interdisciplinary field at the interface of historical macrosociology, cliometrics and mathematical modelling of social processes.

Cliodynamics should be related to cliology.[2] Turchin relates the founding of cliodynamics to 2003. The emergence was made possible by data that can be used in mathematical modelling applications. Models need to be fed with data. A working historical microscope is to be the *Seshat* project - a databank of global history.[3] Applied - e.g. in (Turchin, 2024) - is a structural-dynamic approach. A single scientist can cover a limited number of historical narratives. However, cliodynamics gathers a vast amount of knowledge and then has to apply it.[4] Mathematical models are constructed that trace the internal mechanisms of social systems of aggregated millions of individuals, even fictional ones.[5] States are conceived as complex dynamic systems. The science of these is already supposed to work in explaining biological or physical systems. It has yet to be so developed for social systems. The first question in the study of systems remains its structure. Society should be modelled through various interest groups (e.g. elite groups) to which a structural-dynamic approach is to be applied.

The book (Turchin, 2005) is presented as a provocative cliodynamic essay. Here, scientific laws are also sought to be the basis of history, focusing on the cyclical patterns of war and peace. Empires are supposed to sprout along *"meta-ethnic boundaries",* where conflicts between foreign nations are supposed to promote the social solidarity and discipline that empire building requires. Successful societies are to emerge in border zones between different cultures, defined by language or religion, or between different types of settlement. Some societies are supposed to be able to transcend the vision of the individual or small related groups (such as

[2] The science of history as the construction of models of social processes using differential equations.
[3] *Seshat'*s offshoot is the *CrisisDB* database, with about three hundred examples of crises found from the Neolithic to the present day.
[4] In doing so, it supposedly does not practice *"raisin picking"* (choosing only historical examples that fit into the relevant concepts), nor does it succumb to the problem of *"stretching out on Procrustes' bed"* (cutting something off here and there, adding something back in to fit everything into rigid historical cycles).
[5] Turchin does not posit that people always act in their own self-interest. (Turchin, 2015) defends the thesis that the institutions that have made today's extraordinary degree of cooperation possible were created by ten millennia of military conflict.

the family, the clan). Despite narrow self-interests and aspirations in the spirit of rational self-advancement, they are to be programmed to cooperate effectively in building social capital, thereby encouraging the formation of larger political units. However, continued success inexorably leads to decline. Stability and prosperity cause overpopulation and a Malthusian crisis in which the struggle for scarce resources undermines social solidarity and triggers imperial collapse. Turchin bases his theory of pre-industrial empires on an old concept of Ibn Khaldun called asabiyya,[6] which he interprets in terms of societies' capacity for collective action, or collective solidarity. As a major political argument, he claims that societies that generate a high degree of cooperation and adequate social capital (although the relevant physical environment may strongly condition this) should prosper and expand. It is appreciated for its focus on social cooperation as the key to history, rejecting concepts that rely on the selfishness of individuals (and genes) in the struggle for survival. Also, conclusions about the fragility of civilisations with dependencies on the environment. Turchin's studies of collapse also postulate conclusions about the importance of continuous improvement of institutions. However, his broad theory also neglects much, such as the role of personalities in history. Turchin calls the great man theory of history the most anticlimactic.

The Turchin-Korotaev equation (Turchin and Korataev, 2006) attempts to mathematically model the process of intensity of civil wars in history. It is a system of three autonomous ordinary differential equations. The interdependence of population dynamics and intensity of domestic warfare is to be depicted. The hypothesis is that population pressure causes an increase in warfare. The authors of the equations tested the model predictions with case studies. Using ancient China, the Roman Empire, and early modern England. The empirical results were intended to confirm the theory of population warfare. The dynamics of the population variables and the intensity of internal warfare were to be related, with peaks in warfare following population peaks. The rate of change in population was to be negatively affected by the intensity of warfare, and the rate of change in warfare was to be positively affected by population density. However, problems persist not only at the mathematical level. Many factors (e.g., mentality, politics) that are not considered may influence the emergence of conflicts.

Similarly, with Turchin's discovery of the iron law of social development. The material (Turchin, 2010) predicted a time of unrest (not only) in the U.S. around 2020. The main reason was supposed to be that too many elites did not have adequate employment. The text (Turchin,

[6] Originally in the sense of selfless cooperation in the clan, etc.

2012) analyses crises in the USA. It traces a cycle, regularly recurring, lasting about 50 years with peaks around 1870, 1920 and 1970. The main factors causing uneven development and instability are sought in the internal dynamics of society. These are not meant to be cycles in the mathematical sense that can be calculated. Turchin generally uses the word cycle as a recurring and clearly defined phenomenon[7], but the actual length may vary. Cycles of around 50 years are thought to be related to the genetic makeup of humans or the succession of generations. The generation that has experienced the crisis is able to fight against its symptoms. The following generation can also cope while the older generation is still alive. After they have gone, the whole process is to be repeated. Turchin finds the existence of cycles in all agrarian societies for which there are more accurate records (China, the Middle East, Southeast Asia). However, they may not always be cycles of 50 years. The implication is that general patterns lead to secular cycles, regardless of the regional or historical context.

The explanation is associated with structural demography. The surplus of labour in relation to limited labour opportunities is supposed to put pressure on institutions. This is supposed to manifest itself in continuous pressure on price inflation, in the reduction of real wages, in rural decline, in migration to cities, and is supposed to lead to an increased frequency of protests against current wages and food looting. At the same time, the rapid growth of the young educated generation is resulting in the so-called overproduction of elites. Applicants for elite jobs outnumber them. The pressure for positions further leads to the development of interest groups. Networks (linked by family or professional ties) emerge that displace those outside these structures in competition for increasingly scarce resources. Interest groups are formally non-partisan, organised and involved in political activities. They lobby for their own interests, which usually do not coincide with the public interest. As a result of these trends, the bureaucratic apparatus and the army, or the state forces, are growing. All of this is to culminate in a fiscal crisis, with resistance from the elites and the people, and the erosion of central power. There is also a struggle within the elites (within the authorities, political parties, economic elites, etc.). Another part of the cycle begins, and the social contract ends.

Turchin tests the theory on the number of internal conflicts in the U.S. during the period under study. He identifies a total of 1,590 unstable, conflict events, and their distribution over time is not intended to be uniform. Nearly 60% of all conflicts are associated with waves of looting, peaking in the 1870s, 1920s and 1970s. This sequence may also include the period of

[7] Turchin writes critically of historicists who like to flaunt the cyclical nature of history. This is also why he tries to avoid the word cycle in his texts. Instead, he uses the terms oscillations, growth and decline dynamics, or civilisation rhythms.

unrest around 1830 and possibly the American Revolution of 1775-83. Turchin compares American history with similar trends in other civilisations. He notes that intra-state divisions, not inter-state wars, are behind most conflicts today. Turchin notes an increase in the frequency of intrastate conflicts, for example, compared to the 1960s. He draws the relevance and predictive power of his conclusions from the number of internal conflicts in the long run.[8]

2 Risk factors for the collapse of human societies

Based on complex mathematics and welfare data, the book (Turchin, 2024) models the built-in self-destruction mechanisms of city-state era civilisations. The key drivers of instability are supposed to be property inequality with widespread impoverishment and elite overproduction. Here again, Turchin relies on structural demography theory, examining long-term political stability and instability cycles. Turchin looks for historical examples, focusing on the deeper causes of the contemporary U.S. crisis. Turchin's model posits that the extraordinary wealth flowing to the elite eventually creates problems for the holders of that wealth themselves, who are in power. The social pyramid has grown too wide at the top. There are too many contenders for the elite for the limited number of upper echelons in politics and business, which he calls the overproduction of the elite. This, along with general impoverishment, leads to conflict within the elite. It undermines civic cohesion and the sense of national cooperation without which the state disintegrates. Social fragility is growing, manifesting itself in the collapse of trust in institutions, in the disintegration of social norms (governing public debate) and democratic institutions. In addition to the overproduction of the elite, Turchin introduces another aspect of social stability into the model, which is general impoverishment, breeding discontent, and ultimately anger. The general discontent, together with a large group of elite aspirants, forms an explosive mixture that was to result in the first election of Trump. The twin forces of elite overproduction and general impoverishment should have brought Lincoln or the Chinese emperor Ch'ung to power.

The book is to be based on evaluating large data sets on human behaviour. However, Turchin does not want to lose sight of real human beings by modelling impersonal elites, so he also tells short archetypal stories with numerous precedents in reality. The heroes of his stories, however, are fictional characters. The structural demographic drivers of instability in the form

[8] Regarding the fulfilment of the 2020 prediction (Barta, 2021), he notes the large number of Covid-19 infections in the USA, the threat of an escalating trade war with China, including the return of American companies from China. The second factor of instability was the death of a drugged criminal African American in May 2020. Protests broke out, with looting, and American symbols were destroyed. Trump loses the election, and America is as divided as ever. The crisis year was to culminate in an attack on Congress in January 2021.

of general impoverishment and elite overproduction are meant to illustrate the importance of structural demographic theory as part of cliodynamics. Meanwhile, structural analysis of revolutions and state collapse is often criticised for neglecting, for example, ideological and cultural factors.

The development of cliodynamics is intended to allow modelling of multiple pathway type predictions. This is what Turchin is trying to do by predicting the trajectories of U.S. development in the turbulent 1920s of the 21st century. At the heart of multi-path forecasting type modelling is the relative wage and the wealth pump that drives it. When the relative wage falls, it leads to impoverishment and overproduction by the elite. The number of radicals is supposed to be the key variable being tracked. Regarding the subject of change, Turchin emphasises aspirants to membership in the elite, of which there is a surplus. In the finale, Turchin states the establishment of a revolutionary situation in the U.S. The ruling class in the U.S. has two ways out of this situation - its overthrow or social affirmation through reforms that will rebalance the system and reverse the current trend of general impoverishment and overproduction of the elite. The analysis concludes that there should be very few cases in history where a society has gone through a crisis with little or no loss.[9]

3 Mathematical modelling of secular long-term cycles

Turchin's quantitative historical analysis is meant to reveal that complex human societies are affected by recurring and predictable waves of political instability. Stagnant or declining real wages, a growing gap between rich and poor, an overproduction of young college graduates, and exploding public debt are all supposed to be present in today's U.S. These disparate indicators are supposed to be dynamically linked. The indicators were to experience turning points during the 1970s. Historically, their evolution has served as a leading indicator of impending political instability. Initially, Turchin, in his search for key factors in the dynamics of history, operated with about 40 factors derived from politics, economics or the frequency of front-page news. He gradually arrived at a cycle of about 50 years, 1870-1920-1970-2020, which he elaborates on in several books. Very long *"secular cycles"* are supposed to interact with shorter-term processes, including cyclical ones. In the U.S., the 1870s, 1920s, and 1970s

[9] Turchin cites some optimistic cases (e.g., the early modern British and Russian empires, while the impact of the reforms was temporary and even these societies eventually ran into trouble). Meanwhile, a happy ending other than capitalist liberal democracy is unimaginable for Turchin's stories. However, the intrinsic connection between the plutocratic elites criticised (mildly) by Turchin and the ideology of liberal democracy is not included in his models.

were each supposed to have a half-century increase in instability, so Turchin predicted the next increase to occur around 2020.

This is supposed to correspond with the decline of the long K-wave, following the 40-60-year growth of economic cycles. The synchronisation is supposed to result in the severity of future recessions.[10] In addition, the second decade of the 21st century is to see a rapid increase in the number of twenty-somethings, similar to the youth storm that accompanied the turbulence of the 1960s and 1970s. All of the cycles mentioned above are expected to peak around 2020. Historical data should show that societies can avert disaster. According to Turchin, ways must be found to mitigate the adverse effects of globalisation. Economic inequality, accompanied by rising public debt, is to be addressed by more progressive tax rates. Moreover, we should not expand the education system beyond the capacity of the economy to absorb university graduates. The surplus of young people with higher education should have been one of the main causes of political instability in the past.

Turchin (and others[11]) contribute to the mathematical modelling of secular (long-term) cycles. In the sense of cycles, primarily sociodemographic.[12] By modelling the dynamics of systems, they are supposed to show that these cycles were a fundamental characteristic of complex agrarian systems (and not a specific Chinese or European phenomenon). In doing so, both trend and cyclical components, including interactions, are traceable in the historical dynamics. The models operate with the following logic: After a population reaches the ceiling of the carrying capacity of the land, its growth rate declines to values close to zero. The system experiences stress with a decline in the standard of living of the general population, increasing the risk of famines, insurgencies, etc. Most complex agrarian systems should have had considerable reserves of stability, but within 50-150 years, these reserves have usually been exhausted and the system has undergone a demographic collapse (Malthusian catastrophe). Increasingly severe famines, epidemics, an increase in internal conflict and other disasters led to significant population declines. As a result of this collapse, spare resources became available, per capita production and consumption increased substantially, population growth resumed, and a new sociodemographic cycle began.

[10] The synchronisation of forces, cycles and rhythms was to occur in many countries even in 1968-72. This is the period of the peak of (not only) economic IV. K-wave. Which is also true for the years 1870 and 1920 mentioned by Turchin, corresponding to the peak of the II. and III. K-wave. With 2020, respectively the peak of the originally predicted V. K-wave, the situation remains more complicated. Cf. (Džbánková et al., 2021).
[11] S. A. Nefedov, A. V. Korotayev or S. Malkov - cf. (Turchin, et al., 2007).
[12] Cf. (Turchin, 2009).

The book (Turchin, Nefedov, 2009) describes the long-term cycles of rise and fall of great empires and societies throughout history. It operates with models having two main structural-demographic phases, each with two sub-phases. These are the integration phase (subphases of expansion (growth) and stagflation (compression)) and the disintegration phase (with subphases of crisis (state breakdown) and depression/intermediate cycle). Intermediate cycle refers to a situation where a functioning state collapses and takes some time to recover. Elites are characterised by the following features in the subphases: low population and consumption; growing population, competition and consumption; high population, conflicts, high inequality; declining population, downward mobility, declining consumption; population evolves as follows: growth, slow growth, decline, slow decline. State power and collective solidarity: growing, high but declining, collapse, attempt to rebuild. Sociopolitical instability: low, rising, high, declining. Disintegration phases do not usually take the form of continuous chaos, but instead alternate between periods of strife and periods of relative calm. These alternations typically last for about two human generations (40-60 years), and Turchin calls these *"father-son*" cycles.

Turchin's quest for scientific exactitude is at times overstated, which is to be seen in the concept of historical cycles of unclear periodicity, riddled with highly obscure factors *ala "mathematical chaos"*. Turchin tries to avoid deterministic conclusions, but his models (not only of the various cycles) often appear highly mechanical and inadequately reflect the role of unique, unpredictable factors that can influence the dynamics of development.

4 Background to long K-wave concepts

Turchin cycles are usually not in fundamental conflict with the theory of long K-waves in the sense of economic cycles[13] or more broadly socio-economic cycles. Including the concept of opening and formative crises associated with the turning points of long K-waves.[14] However, Turchin's cycles stand *"on the water"* even more obviously than economic long cycles, or waves, which standard economics to this day largely ignores or outright rejects.[15] Which can be applied to economic cycles in general. In explaining fluctuations in actual output around

[13] The alternation of intervals of high sectoral growth and intervals of relatively slow growth using modern methods in the world economy is demonstrated, for example, by (Korotayev, Tsirel, 2010).
[14] The upper turning points of the K-waves can be associated with opening crises (1810-1871, 1917, 1968), raising new historical questions and historical tasks, including transformations of the social order. The period of long waves can be associated with so-called formative crises (1848, 1896, 1939-45), including preludes or interludes. Cf. (Sirůček, 2016).
[15] Cf. (Sirůček, 2001).

potential output (e.g. AD-AS models), contemporary standard economics attributes a major role to shocks.

Turchin's secular cycles or predictions of political instability after about 50 years can be linked to the concept of long K-waves without much difficulty. Let us stress, however, that their explanation by the mechanism of innovation logic (in the spirit of J. A. Schumpeter, with reference to N. D. Kondratieff and continued by, e.g., F. Valenta) applies only to industrial history. Numerous ambiguities persist in the post-industrial era.[16] It would be even more problematic to extend the above to pre-industrial societies, which often model precisely the cycles of Turchin.

Let us recapitulate the sequence of innovative long K-waves in industrial history, with a link to the Industrial Revolution (IR). Modern industrial society began with the 1IR Revolution in England. This becomes the material base of the I. K-waves (1780/90-1844/51), consisting of a long expansion phase (1780/90-1810/17 (upper turning point)) and a long depression phase (1810/17-1844/51). II. The K-wave is usually dated 1844/51-1880/96, with the long expansion of 1844/51-1870/75-76 (the upper turning point) based on developing railways, metallurgy and engineering. III. K-wave occupies the years 1880/96-1939/45. The long expansion of 1880/96-1914 (with a turning point of 1914-17) exploits new forms created in the previous depression and is based on the development of the 2IR. IV. K-wave comes in the storm of II. SV is carried by the 3IR. Its dating is not uniform: 1939/45-originally around 2000 (but earlier). The long expansion lasted from 1939/45 to 1965/70. The 1965/70 period (upper turning point) begins the long depression of IV. K-wave. But what next? The originally predicted V. K-wave, with a tipping point of 2020/30, remains debatable. There is relative consensus on the I.-IV. K-wave.[17]

Let us recall that attempts to variously link the long wave theory with social processes into the so-called *"organic theory"* of long waves (F. Braudel, F. C. Spooner, P. M. Sweezy), with the labour movement (E. Hobsbawm, J. Bouvier, E. Screpanti, etc.), long-term cycles of "global force" according to G. Modelski,[18] cyclical movements of *"capitalist world-economy"*

[16] Cf. (Džbánková et al., 2021).

[17] Some say that the 5th K-cycle was supposed to end the 2000-03 crisis and start a new cycle. The vehicle is to be health in its holistic conception, including physical, mental, social, ecological and spiritual aspects. Psychosocial health and biotechnology are the core innovations. Others date the 6th K-wave 2020-30 to 2050-60 and associate it with MBNRIC (med-bio-nano-robo-info-cognitive) technologies. They emphasise health services and fully scientific cybernetics. For the 5th K-wave (1980-2020), microelectronics, personal computers, high-skilled services and the beginnings of scientific cybernetics were to be key. Cf. (Džbánková et al., 2021), (Sirůček, 2016).

[18] Cf. (Modelski, 1987). The model describes the connection between war cycles, economic domination and political aspects of world leadership. In the end, the title of the most powerful nation in the world changes. Modelski divides the cycle into four phases. If periods of global war are included, the cycle can last 70 or 87-122

I. M. Wallerstein, etc. Many overlaps, interfaces, and correlations with economic cycles can be found and discussed.

The more general questions of the determinism of development and the possible direction of history in the context of different worldviews, philosophical and ideological anchorages, remain problematic. The interconnection of relatively independent spheres of socio-economic reality, including mediating mechanisms, awaits a much more thorough interdisciplinary elaboration in attempts to comprehensively grasp the dynamics or cyclical nature of development.

5 Limits of cliodynamic modelling

An evolutionary biologist versed in mathematics and statistics, P. Tuchin is an enthusiast, firmly convinced that he is presenting the right stories from history. In a more popular domestic environment (without mathematical apparatus), Turchin's cycles and predictions are happily handled by V. Cílek or M. Bárta (Barta, 2021). P. Turchin models not a linear development of societies. However, a series of social cycles, nested within each other, including the mechanism of multistage selection, according to which human civilisations are supposed to develop. His theory of secular cycles helps to explain the collapse of historical civilisations. The aforementioned complexity, enhanced by mathematical and statistical apparatus, allows Turchin's theories to avoid accusations of being too simple (and naive).

P. Turchin's seductively misleading - and, let us face it, mostly *"catchy*" for the reader - cliodynamic modelling of history provides an interesting view of society and different historical epochs, including many inspirations. Also related to applications of the structural dynamic approach using the tools of complex systems science. Turchin's ability to link historical data with the analysis of contemporary events, the persuasiveness of his argument thanks to the abundance of data and examples, as well as his ability to link different disciplines (history, sociology, political science, economics, etc.) in an attempt to provide a comprehensive view of crises, not only contemporary ones, is appreciated. Alongside efforts to understand long-term trends, Turchin seeks to generate plausible scenarios for future developments. However, does not the pursuit of exactitude through quantitative methods - and at all costs - mask the superficiality and naivety of these theories and models?

years. Modelski's theory sees war and other destabilising events as natural products of the long cycle and cyclical development of the global system. The first hegemon was to be Portugal in the 16th century, the Netherlands in the 17th century. Next, Great Britain twice, during the 18th century and then the 19th century. The U.S. has been the hegemon since the end of World War II. He describes five long cycles that have occurred since about 1500, each intended to be part of a larger global system cycle, including strong correlations with economic K-waves.

Conclusion

Cliodynamic methods, models and conclusions certainly cannot be overestimated. It belongs to the popular *"data mining"* stream, which also affects historical science. Cliodynamics does not rewrite human history, even if it is often over-interpreted as such. What is often marginalised or outright ignored is that mathematics is the language of the natural sciences, and it behaves accordingly. Based on historical experience, we should keep a greater distance from the predictions of mathematical modelling. An example is the models of the metalloid pandemic, where the media chose the most apocalyptic ones, often from minimally dubious so-called experts. It is not only economic damage that is caused by the mathematical modelling of financial and other crises. Let alone climate models, whose uncritical worship leads to damage on a global scale, which is often irreversible. It can be agreed that mathematical modelling is a *'good servant but a bad master'*. It is impossible to fit human history into mathematical formulas.

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