Introduction.
On the Forms, Patterns and Modes of Evolutionary Development

Leonid E. Grinin
HSE University, Moscow; Institute of Oriental Studies, RAS, Moscow

Andrey V. Korotayev
HSE University, Moscow; Institute of Oriental Studies, RAS, Moscow

The present Yearbook which is subtitled *Historical and Technological Dynamics: Factors, Cycles, and Trends* demonstrates different forms, patterns, and modes of evolutionary development of societies and their subsystems both over very long periods (in fact, the whole historical process) and over relatively short time intervals. Thus, it makes sense to say a few words about the forms of realization of these trends and processes. Of course, systematic description is out of question, as it requires detailed work. Thus, these are just ideas.

We believe that without an in-depth analysis of the forms and mechanisms of development, it is more difficult to understand both the dynamics of the historical process and many contemporary issues rooted in history. There are a number of theories including the theories of social evolution that have contributed and continue to contribute in this direction (*e.g.,* Spencer 1898; Carneiro 2000; Claessen 1989, 2000; Hallpike 1986; Voget 1975; Grinin and Korotayev 2009a; Grinin 2020a; Grinin L. and Grinin A. 2020a, 2020b), progress (see Nisbet 1980; Grinin 1997, 2006, 2009; Grinin and Korotayev 2009a; Korotayev 2003), civilizations (see, *e.g.,* Spengler 1993; Toynbee 1991; Eisenstadt 1997; Yerasov 1998), world-systems (see Braudel 1986–1992; Frank 1990; 1993; Frank and Gills 1993; Wallerstein 1987; Amin *et al.* 2006; Arrighi 2006; Grinin and Korotayev 2009a; Korotayev, Malkov, and Khaltourina 2006a, 2007), historical globalization (see O'Brien 2006; Berg 2008; Grinin 2011b; Korotayev, Malkov, and Khaltourina 2005, 2006b), Big History (see Christian 2004; Spier 2011; Nazaretyan 2009; Grinin, Korotayev, and Rodrigue 2011).[1] However,

[1] It is also worth mentioning the use of general theory of systems (see, *e.g.,* Bertalanffy 1969a, 1969b; Sadovsky and Yudin 1969) and complexity theory as applied to social research (Prigogine

each of them has its limitations and vulnerabilities (for more details see Grinin 2007c; Grinin and Korotayev 2009). New approaches as well as a synthesis of macroapproaches are required that would allow us to consider social development on different scales and at different levels, in different areas of social and socio-natural reality. For this purpose, it is important to study not only contemporary, but also retrospective processes.

Evolutionary development of societies has followed different paths and has been realized in a great variety of forms for a long time. The idea of the multilinearity/alternativity of social evolution (see Korotayev 1992, 1999, 2003; Korotayev *et al.* 2000; Grinin 2007b, 2007c, 2007d; Grinin and Korotayev 2009; Bondarenko, Grinin, and Korotayev 2010; Grinin 2009b, 2011a; Bondarenko, Grinin, and Korotayev 2011) leads us to understand that in the process of coexistence and competition of societies and institutions there appeared numerous forms of relations and institutions, of which only a few have proved to be evolutionarily promising.

Therefore, the view that all societies and peoples have the same stages of development and differ only in the timing of their passing through is fundamentally incorrect. Evolution should not be compared with a wide ladder, along which sooner or later all the societies will move independently in the same upward direction. It should be rather compared with an extremely complex labyrinth, an arogenic way out of which can be found without borrowings only by a very few societies (yet, even such societies may only find independently a part of this way, whereas no society has managed to find the whole of this way without any borrowings from the other societies). In other words, the evolution of a specific society cannot be usually regarded as a small-scale repetition of the main line of the arogenic evolutionary development. This can only be done with respect to a very few of them, only for certain parts of their history (and always with very considerable reservations). The point is that throughout most of the human history the evolutionary breakthrough to a new level (aromorphosis) in one place (society) could only take place at the expense of destruction, stagnation, movement sideways of many other societies. This principle was denoted by us as 'the rule of payment for aromorphic progress' (see Grinin, Markov, and Korotayev 2008: 80–81).

Here, it is also worth mentioning *the Rule of multidirectionality of evolution* which was formulated by us. The emergence of a new evolutionary level does not cease the processes characteristic of the preceding levels, and variability continues to grow. However, fundamentally new qualitative breakthroughs from these levels may be significantly hindered because evolution has already reached new levels of development (Grinin 2017: 158). At the same time, dif-

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and Stengers 2005; Borodkin 2002; Malkov and Korotayev 2005; Malkov 2009; see also Grinin 2011b, 2012b: 283–284).

ferent alternatives and analogues of evolution can, figuratively speaking, converge and diverge, creating options that are fundamentally opposite in one way or another, particularly in the level and pace of development, but then those lagging behind can catch up with those ahead of them and in turn become leaders. So, we have formulated the rule of convergence – divergence (Grinin 2017a: 160). There are always lines of convergence and divergence in the development of a group of similar objects. Divergence and convergence between East and West is analyzed in detail by us in previous studies (see Grinin and Korotayev 2015; Grinin and Korotayev 2016; Grinin 2017b, 2020b).

It is also important to mention *the rule of optimal conditions and proportions required for certain processes or changes* which means that the deficiency and excess of resources can significantly change the development path and proportions of a system (Grinin 2017a: 161). Resource deficiency limits the living space required for the normal existence of an object (organism) or the functioning of a system. An excess can reduce developmental incentives and lead to disproportionality.[2]

Any system strives for stability, but there are many circumstances that prevent societies from remaining in a state of long-term stability. And the denser the social space is, the more circumstances arise. Also, there are constant fluctuations in different subsystems, for example, the inflation processes alternate with deflation and vice versa (Grinin and Korotayev 2018). And the phases of stability are regularly replaced by crisis, decline, collapse, *etc*. In other words, in their life cycle societies from time to time fall into the traps created by the previous development. One should mention *the underdevelopment trap* into which the societies that are unwilling or unable to develop the necessary technologies and attitudes fall. It is the danger of becoming (or remaining) weak that forces states to modernize, to strengthen and to make breakthroughs. Much less evident is *the development trap* for social systems that are actively developing and in some respects are leaders or at least exceed the average level of development. Overall, we can say that the trajectory of life of societies and – more broadly – of social evolution lies between the Scylla of underdevelopment and the Charybdis of over-accelerated development. In the latter case, in the future the price for success today will be crisis and setback. For example, the countries of the Middle Ages and Early modern period that were able to achieve domestic peace, economic development, to increase trade, urbanization, *etc.*, turned out to be in thrall to their achievements. The fact is that advances in state and agricultural development led craft-agrarian societies into a Malthusian trap from which they could escape only within the Industrial production principle. Unexpectedly for their rulers (and quite expectedly from the point of view of

[2] The resource trap, better known as the 'resource curse' (see, *e.g.* Auty 1993) is worth mentioning here.

system analysis) in a country where there had recently been a shortage of workers, the population began to grow rapidly precisely because of favorable conditions. Consequently, the problems of overpopulation, land scarcity and, as a result, a social crisis increased dramatically. And since, in difficult times, as the proverb says, it never rains but it pours, there were usually (and not without reason) other problems (crop failures, political crises, resource deficiency, *etc.*). There were also wars and epidemics which led to socio-demographic collapse. Not surprisingly, overall population growth until recent centuries was relatively slow, with frequent setbacks.

Modernization traps are another type of traps for rapidly evolving societies. They are formed because many traditional institutions, attitudes, as well as ideology, fail to keep pace with changes in technology, communications, trade, education and medicine. As a result of such imbalances, radical sentiments grow in societies, and a revolutionary crisis emerges. The crisis is exacerbated by the fact that the changes in the way of population reproduction (*i.e.* demographic transition/demographic modernization), connected with declining mortality while maintaining high fertility for a long period of time, lead to unprecedentedly rapid population growth. Thus, in general terms, rapid (accelerated) development in various areas is the cause of a systemic crisis that can be extremely damaging to society, but at the same time is a powerful source of the search for innovation (see Korotayev *et al.* 2011; Grinin 2012a, 2013, 2018b, 2019a, 2022b).

We have already noted that revolutions are a very costly and dangerous way of social development (see, *e.g.,* Grinin 2007b). Although other, much more efficient forms of development have long been developed, unfortunately revolutions still remain a common way of solving social problems (see also Grinin, Korotayev, and Malkov 2010). Moreover, despite the fact that in the 21st century the significance of revolutions as a way to achieve new levels of development and form new advanced models of development has fallen dramatically, their number is still growing (see Grinin 2018a, 2018b, 2019b, 2022a, 2022c, 2022d; Goldstone *et al.* 2022).

Cyclical dynamics in the life of societies was already noticed by the ancient historians (*e.g.,* in the works of Polybius), and later Ibn Khaldun and Machiavelli formulated quite elaborated theories of cyclical socio-historical dynamics (see, *e.g.,* Grinin 2010a, 2012b; Korotayev 2006; Korotayev and Khaltourina 2006). Economic cycles are the best known, especially Juglar and Kondratieff cycles (Grinin, Korotayev, and Tsirel 2011; Grinin and Korotayev 2012; Grinin and Grinin 2014, 2021; Grinin, Grinin, and Korotayev 2017; Grinin and Korotayev 2014; Grinin 2019c). But cycles occur in different subsystems, including political ones (Grinin, Devezas, and Korotayev 2014).

Kondratieff cycles are called long waves, lasting approximately 50–60 years. However, we have distinguished technological ultra-long cycles which

we call production principles. Unexpectedly, we have found a close correlation between them and Kondratieff cycles (Grinin 2019c; Grinin and Grinin 2021). The correlation between cycles is a very common pattern, which demonstrates the basic unity of many processes.

Among different types of cycles, one can distinguish the ones which can be called developmental or evolutionary cycles. These are cycles that do not repeat completely, but partially retain what has been achieved because after a setback society was still beyond the starting point from which the rise began. Georg Hegel already pointed out the prevalence of such spiral cyclic development. Cyclic forms of development are not a thing of the past, they still remain important in modern life and even increase their significance in some respects, for example in economic rhythms. This is evidenced by the enormous interest in various cycles in modern science.[3]

Evolutionary cycles mean alternating up and down movement as an inevitable consequence of a breakthrough in development. The backward movement marks the emergence of a more or less severe crisis in society. This is why many cycles have crises as their focal points.[4] But crises are not just a turning point in cyclical movement but they are also an opportunity to find new answers to the challenge of environmental, production, social, ideological and other constraints. Even the partial removal of such constraints is always a major evolutionary step. However, not all societies manage to take this chance.

If we observe in a number of societies, and for a sufficiently long period of time, a regular repetition of the same type of cycle ending in a severe crisis and a significant setback, this means that at a given level of development there are such severe systemic and environmental limitations that the society is not able to overcome. In other words, there is a trap in the course of social evolution that does not allow for a phase transition to a new level of development. The Malthusian trap, which severely limits population growth and consumption, represented just such a situation. The persistence of highly complex social systems in this trap led to periodic severe crises (often taking the scale of socio-demographic collapses/catastrophes), setbacks. Periodically, there have been

[3] As Abel and Bernanke rightly point out, '...the business cycle is one of the basic concepts of macroeconomics because fluctuations in economic development, the phases of the business cycle – ups and downs in general economic activity – affect the whole economy' (Abel and Bernanke 2008: 361).

[4] It should be noted, however, that not all economic cycles have distinct crisis phases. Medium-term (Juglar) cycles have such a feature, and long Kondratieff cycles, demonstrating wave dynamics, do not have their own crisis phases (they coincide with the cyclical crises of Juglar cycles). As for the medium-term cycles, within their framework the economy develops from crisis to crisis, from cycle to cycle, because the expanded production is not predetermined, does not occur automatically, but requires great effort, stimulation, on the way of which there are constant obstacles. A recession (which brings the system to a new equilibrium) and a certain restructuring are necessary to continue moving forward.

attempts to escape from this trap.[5] For a long time it was not possible to do this, but these attempts in the long run led to a systematic growth of the level of technological development of the World System. As a result, at the level of certain social systems, socio-demographic collapses occurred after these systems had reached ever higher levels of population size and socio-cultural complexity.[6]

The notion of 'a trap' is not sufficiently used in social sciences. Yet it is very expressive and could be used to describe *a steadily (regularly) recurring situation in which development beyond a certain level, set by the features of the society, its certain spheres and environment, inevitably sooner or later creates systemic imbalances, leading to periodic states of tension, then crisis of the society and eventually setback.* In the language of complexity studies, the notion of a 'trap' will correspond to a certain, but far from complete, extent to the notion of 'attractor'. The difference is that approaching the attractor in relation to social systems is only sometimes associated with the occurrence of a severe crisis, whereas, once trapped, a social system almost by definition experiences a more or less serious crisis. One should note that sustained escape from the trap would largely correspond to the phase transition.

We have already mentioned the rule of payment for aromorphic (evolutionary) progress according to which multiple attempts by different societies to find paths to the new level are used to ensure an evolutionary breakthrough. It is worth revisiting this point to see how historical selection works.

This can be clearly seen from the case of the formation of the state. It took thousands of years for the evolutionary advantages of this new political form to become distinct and dominant. But at the same time, tens of thousands of political organisms disappeared as autonomous, irreversibly having lost the possibility to become such.

Why, for example, did not Rus's neighbours, the Pechenegs and Cumans, create a state? Why did not the Gauls have a state, although in terms of culture, population, development of cities and trade they noticeably surpassed many others, for example the Saxons and Angles, who conquered Britain? (On the

[5] In the case of the Malthusian trap, population decline for some time reduced land shortage and increased the standard of living of the remaining part of population.

[6] Thus, during socio-demographic (and dynastic) cycles in China the population level, the excess of which was followed by a socio-demographic catastrophe, rose from 50–60 million people in the Han, Sui and Tang Dynasty period in China (*i.e.* from the last centuries B.C. to the beginning of the 10th A.D.) firstly up to 100 million people during the Song dynasty in China (10th – 13th centuries), up to 150–200 million people during the Ming dynasty in China (14th – 17th centuries) and then up to more than 400 million people in the period of the last Qing dynasty (see, *e.g.*, Ilyushechkin 1986: 207; Dikarev 1991: 71–72; Krukov *et al.* 1979, 1983, 1984, 1987; Khokhlov 1972: 30; Korotayev, Komarova, and Khalturina 2007; Korotayev, Khalturina, and Bozhevolnov 2010; Grinin 2010b).

very high level of development of pre-Roman Gaul see, *e.g.,* Chadwick 1987.) A closer analogy can also be made. Were the processes of unification of small, ethnically close polities (principalities, duchies, urban republics, *etc.*) into large centralized states inevitable in the framework of the World System of the late Middle Ages and the early period of Modern History (the 15th – the 18th centuries)? Of course, there is no question about that. However, there were not such states during that period in Italy and West Germany. They began to emerge much later under decisive outside influences. And in Poland, for example, a strong royal power was never established. As for Russia, one should mention that it deviated from the seemingly inevitable (in the context of the general evolution of the World System of the 19th and 20th centuries) development towards modern democracy and the strengthening of private property. Even today, the globalization process sharply divides countries and peoples into those who will play an important role in the new globalizing world, and those who will be (at least for the next decades) predominantly the object of globalization changes.

Thus, although it is quite correct to regard the state as an inevitable outcome of social evolution, this is true only in the most general sense, insofar as the state is the result of long-term competition of various forms, their demise, transformations, social selection, *etc.* In other words, it is generally true for the leading line of human development. **But for each society particularly, the state was not inevitable (especially during the periods when it was not yet an absolutely dominant institution).**

After all, the state was not only a completely new solution to the problems facing increasingly complex societies, but also a path that meant breaking with many of the old relationships and traditions. And it is quite difficult and not always possible. Therefore, many societies followed their own path, which, however, often led to different results, in particular to the rapid development of previous tendencies (see, *e.g.,* Grinin 2007a; Grinin 2003; Grinin and Korotayev 2007; 2009: Excursus 6) or the formation of fundamentally new forms of complex political organization, qualitatively different from state systems (see, *e.g.,* Korotayev *et al.* 2000). Such development could lead, for example, to the extreme sacralization of the ruler; to the supercomplexity of kinship relations and the formation of an aristocratic class of privileged clans and kinship lines; to the complication of horizontal (instead of vertical hierarchical) relations; to the rigid establishment of professional and social differences (caste system); to the creation of tribal, civil community or urban confederations without strong central authority (but with effective alternative mechanisms of intersocial integration), or to other models. However, the choice of development path is always linked to many specific historical reasons (for more details see Grinin 2007a; 2007b; Grinin 2003, 2004; Grinin and Korotayev 2009: Excursuses 3–6).

Often, the fate of a certain society also depends on chance, especially in times of unstable, bifurcational situations. In particular, with the emergence of states and other complex political systems in many changing societies there could arise some kind of bifurcation zones in which some or other, seemingly not too significant, events could play a decisive or even a fatal role. For example, Genghis Khan, even before he was proclaimed the supreme khan, escaped death several times by a miracle, and once he was searched for by three hundred horsemen chasing him. But who knows how many khans were killed? However, if he died, there would be no giant empire. In fact, according to the history of nomads, sometimes hundreds of years had passed until there appeared a leader who could unite them. And the Mongol empire should be considered as 'a unique creation' (Barfield 1991: 48). In Modern times, bifurcational situations were particularly frequent in the period of revolutions, during which the role of personalities and related contingencies increased tremendously (see Grinin 2008).

Thus, on the one hand, any evolutionary leap is prepared by all previous development and experience as a result of unsuccessful attempts to find a new path, by the increasing 'problem solving' needs, until the macroevolutionary line approaches the point with the best conditions for a breakthrough. But on the other hand, where and how it will happen is a matter of a particular historical case and the coincidence of special conditions and circumstances. Consequently, although a particular innovation or even an evolutionarily significant aromorphosis (later adapted by a number of societies) very often appears in a particular society at a particular point in time and as a result of special conditions, it is obvious that the causes and conditions of the appearance of this evolutionary change cannot be sought only in the features of the society that generated it. Whatever particularly favourable conditions were created for the emergence of social aromorphosis in a given society, they were always created due to the development of many other earlier and contemporary societies, even if their efforts were unsuccessful or meaningless. And they were often prepared precisely by such unsuccessful searches for new paths (in fact, this is the above-mentioned rule of 'payment for aromorphic progress', and the 'rule of the aromorphic relay-race' [Grinin, Markov, and Korotaev 2008: 37–39] can also be used here).

Thus, the concept of 'selection' is very important for the understanding the historical destinies of societies. Selection is universal and can be observed at any phase of evolution and in many different forms. But speaking of it primarily as Darwinian selection clearly narrows the scope of the concept and greatly distorts the processes, since Darwinian selection as a non-directional process of gradual change is clearly narrow even for biology, not to mention other phases of evolution. But the predominance of the so-called synthetic theory of evolu-

tion in biology also negatively affects the whole studies of evolution. It is obvious that Darwinian selection is just one of many forms of selection. Other forms are diverse. For example, G. A. Zavarzin speaks of selection based on symbiogenesis (*i.e.* symbiosis between different organisms, such as animals and bacteria, fungi and higher plants), a widespread phenomenon in the living world (Zavarzin 2007: 127). Here, there is selection for the greatest capacity for symbiogenesis of particular species. One should add that selection can be based on the 'friend or foe' principle, *i.e.* it is not selection for survival, but for the possibility of cooperation (in particular, this is true for chemical formations and crystals). In terms of realization of evolutionary possibilities, there is always a selection of conditions, *i.e.* the most favorable conditions (*e.g.,* with respect to the Earth among other planets in terms of conditions for the origin of life). During self-organization and formation of any structures in the chaos, the selection is based on the 'third wheel' principle, *i.e.* only a few 'lucky' ones remain from a large number of participants (on such selection during formation of planetary and protoplanet embryos see Grinin 2017a). When a number of small objects are merged into a larger system, there is selection of the leader who will take the central position and those who will take the peripheral position. This is a selection by place and role in the future larger system. Thus, the unification of the appanage principalities in Russia demonstrated such a struggle for leadership in the future system between Moscow and Tver. Selection can be delayed: an object or organism having some features gains advantages much later than the acquisition of these features (properties, structural features, *etc.*) that form the basis of that advantage. For example, the first *Homo sapiens* gained an anatomical advantage over other hominids, but they managed to realize it with the emergence of speech much later (in biology, it is gained by the descendants of the first acquirer of such advantage). That is, in fact, the point of preadaptation, which takes place in rare moments of critical changes. Obviously, one can speak of systemic selection (at the level of systems). Also, of course, random and stochastic selection is extremely common. Diversity which is a necessary prerequisite for evolution is inextricably linked to selection, but the fact when and which difference/advantage will be decisive depends on many conditions and circumstances mostly formed by chance. Diversity and selection are the ways for evolution to find the best option under all conditions.

These are only a few aspects of different development options. But they show how diverse the options for evolutionary and historical development are. We hope that the contributions to this issue will enrich the readers with specific examples of this diversity.

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The issue consists of three sections: (I) Long-term Dynamics Factors; (II) Political Cyclicity and Trends; (III) Technological Dynamics and Phases.

Section I 'Long-term Dynamics Factors' includes two articles (**Leonid E. Grinin, Anton L. Grinin, and Andrey V. Korotayev**. 'Technological Dynamics since 40,000 BP to the 22nd Century'), **David J. LePoire**. 'Long-term Dynamics of Ruling Structures in the West, China, and Russia'.

The article by **Leonid E. Grinin, Anton L. Grinin, and Andrey V. Korotayev** ('Technological Dynamics since 40,000 BP to the 22nd Century') considers a long-term dynamics of technological progress, providing one of the options for measuring its rate throughout the entire historical process. The authors are based on the theory of technological (or production) revolutions and the theory of production principles, which allow to measure the speed of technological progress as well as to make some predictions. They have found that the general dynamics of accelerating technological growth over the past 40,000 years can be described with amazing accuracy ($R^2 = 0.99$) by simple hyperbolic equation: $y_t = C/t_0 - t$, where y_t is the technological growth rate, measured as a number of technological phase transitions per unit of time, while t_0 and C are constants, whereas t_0 can be interpreted as a 'technological singularity' point. Although the rate of technological progress since 40,000 BP in general has been increasing, following a hyperbolic acceleration pattern, however, according to the theory of production principles and historical facts, the acceleration of technological progress has noticeable fluctuations. These fluctuations can be explained by the fact that technological development proceeds within the framework of super-long cycles. They show that within these cycles, the phases of accumulation of basic breakthrough innovations are replaced by the phases of rapidly growing improvements and their wide distribution. In their calculations they also discuss the point of singularity and the possibility of radical changing of the previous technological progress pattern. According to their calculations, based on the selection of the most important phase transition periods in technological evolution, the singularity date is expected to happen in the early 21st century.

There is an idea that technological progress has been slowing down from the 1970s. However, as already mentioned, there are strong fluctuations in the acceleration of technological progress. According to the theory of production principles, after the 2030s we expect a new powerful acceleration of technological development followed by its slowdown in the late 21st and early 22nd centuries. Their idea is that global ageing will be one of the major factors of this technological acceleration and then, by the end of this century and the beginning of the next century, on the contrary, it will be a brake on scientific and technological progress. The authors consider the socio-economic mechanisms for such acceleration and deceleration in detail.

In the article by **David J. LePoire** ('Long-term Dynamics of Ruling Structures in the West, China, and Russia') national periodic dynamics are explored

based on government types or dynasties in the West, China, and Russia in the post-Roman/Han era. The period of these cycles is approximately 375 years with some substructure. This analysis first reviews shorter periodic national dynamics from the time scales of political cycles (16 years) and government cycles (72 years) within the United States. Then, the distinct features of long-term periodic dynamics in the West, China, and Russia are explored. The West and China developed relatively independently until the 18th century. During the period of the Roman and Han empires, China has evolved in a rather stable location in contrast to the moving center of Western leadership. In contrast, Russia was influenced by both the East (through nomadic tribes) and the West (through trade and wars). While the average period of about 375 years is seen in all, there is substructure, especially in Russian history that suggests the simultaneous overlap of two frequencies (an additional 450-year cycle). This time frame is consistent with the predator-prey model of two interacting human groups with birth and death rates derived from the expected human lifetime.

Section II 'Political Cyclicity and Trends' includes three contributions.

This section opens up with the article by **Sergey V. Dobrolyubov** ('Simple Bifactorial Model of Structural Cycles Applied to Russian History') according to which the two-factor model (authority-solidarity) proposed in the paper is a theoretical concept that explains the social nature underlying structural cycles. The conceptualization necessarily precedes the quantitative analysis of periods, phases and stages. The model describes the rise and decline of political integrity and collective solidarity of different scales. It takes into account two factors of change – social power and collective solidarity, and considers two structural entities that embody these factors – political organization and society itself. Political and societal entity affects each other and this gives a cyclical pattern to the entire socio-political structure. This structure seeks to expand and at each stage of expansion goes through an administrative and universal phase. The duration of phases turned out to be stable in historical societies and is considered a natural socio-structural constant = 250 years. The structural transformations of Ancient Rus and Russia are considered in terms of that model.

According to **Marc Widdowson** ('Global Fear and Long Range Political Cycles: A Mathematical Model') the Polity IV Time Series of the Center for Systemic Peace can be used to classify world polities since 1800 into autocracies, democracies and 'anocracies' (between the two). The relative fractions of each type turn out to exhibit, to first order, simple mathematical regularities. These are explained by a mathematical model drawing on the anthropology of fear and its observation that political and economic insecurity predispose people to support authoritarian leadership, along with the established result that middling regimes present the greatest amounts of conflict and instability. The result is an oscillation between autocracy and anocracy, superimposed on which there is the spread of democracy through contagious learning. Awareness of

this dynamic can help us understand how present-day conditions may shape world political evolution many decades ahead, as well as get early warning of whether democratisation really is locked in or may be reversed by future fear-inducing events.

Andrey V. Korotayev in his contribution ('Political Centralization and Communal Complexity in Cross-Cultural and Historical Perspective') supposes that the only quantitative cross-cultural attempt to study the correlation between political centralization and communal complexity undertaken by Harumi Befu (1966) found a positive correlation between political centralization and communal complexity. Though Befu's main finding was replicated for the overall sample, a closer inspection of the available data revealed that the real relationship between the two variables under consideration is much more complex (and much more interesting) than Befu stated. The main mistake made by Befu is that he dichotomized both variables as he was sure that there was a linear relationship between them, whereas it turned out to be actually non-linear.

Section III 'Technological Dynamics and Phases' contains two articles.

The article by **Leonid E. Grinin and Anton L. Grinin** ('The Dynamics of Kondratieff Waves in the Light of the Theory of Production Revolutions') attempts to clarify and develop some important aspects of the theory of long cycles (K-waves). For this purpose, the Kondratieff waves theory is correlated with the theory of production revolutions which analyzes the regularities of major technological breakthroughs in history. Both theories analyze the processes of cyclic nature related to the innovative technological development of the World-System. The authors have identified a significant correlation between the duration of the Kondratieff waves and their phases, on the one hand, and the phases of the production principles, on the other. The article consistently describes the features of each Kondratieff wave (and its phases) as stages of the world economic and technological process. At the same time, a number of features of certain Kondratieff waves and their phases, which are insufficiently explained by the theory of long cycles, become more comprehensible if one applies the conclusions of the theory of production principles. Based on the comparison of both theories, the authors make some predictions concerning the development of the fifth and sixth K-waves for the next 40–50 years.

According to **Marc Widdowson** ('From Covid-19 to Zero-Gravity: Complex Crises and Production Revolutions'), pandemics have occurred in the context of complex crises involving other human and natural disasters, including war, rebellion, flooding, and economic collapse. This is because they all derive from increases in population and world connectedness, which produce epidemiological vulnerability, domestic conflict, hegemonic challenge, risky economic behaviour, and environmental over-exploitation. Such complex crises are learning experiences for humanity and, as people solve the attendant prob-

lems, they culminate in breakthroughs in social and material technologies that are sufficiently large and abrupt to be perceived as shifts of historical era. COVID-19 is no exception, occurring amidst growing geopolitical, financial and cultural stresses, and points to what is likely to be a deepening crisis over the coming years. As before, it should generate an unmistakable advance in social institutions and human capacities, which can be identified with Leonid Grinin's forecasted Florescence of the Information-Scientific production principle *c.* 2030–2040. Besides presenting this verbal argument, the paper includes some mathematical explorations to verify the logical consistency of the concepts and their proposed relationships.

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