UNIFIED COMPLEX-DYNAMICAL THEORY OF FINANCIAL, ECONOMIC, AND SOCIAL RISKS AND THEIR EFFICIENT MANAGEMENT: REASON-BASED GOVERNANCE FOR SUSTAINABLE DEVELOPMENT

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Abstract

An extended analysis compared to observations shows that modern "globalised" world civilisation has passed through the invisible "complexity threshold", after which usual "spontaneous", empirically driven kind of development ("invisible hand" etc.) cannot continue any more without major destructive tendencies. A much deeper, non-simplified understanding of real interaction complexity is necessary in order to cope with such globalised world development problems. Here we introduce the universal definition, fundamental origin, and dynamic equations for a major related quantity of (systemic) risk characterising real complex system development tendencies at any level of dynamics. Practically important conclusions are derived, opening further detailed applications in economy, finance and development practice.

In this time of deep and rapid global changes in all aspects of life and activities of the world civilisation, the growing problems of global development criticality, its further directions and related risks acquire the unprecedented and vital importance, with the special, encompassing role of financial risks and economic uncertainty (see e. g. [1-10]). Despite huge efforts applied to understanding and efficient management of respective critical development problems, the dominating unitary, dynamically single-valued science paradigm (including its complexity imitations) *fails* to provide any efficient approach and problem solutions, which should be expected in view of *complexity correspondence* and *complex-dynamical control principles* of our *universal science of complexity* [11-20], implying that the planetary system of extremely high unreduced dynamic complexity *cannot* be efficiently simulated in the framework of over-simplified zero-complexity projection of unitary science, irrespective of computer powers applied. The announced crucial goal of *sustainable development* (e. g. [1]) becomes thus seriously compromised.

In particular, usual theory fails to provide the universal and consistent *definition* itself of risk or stability, even in separate fields of financial and economic development, let alone the related efficient strategy to cope with the emerging critical phenomena and the *intrinsically unified*, globalised character of culminating changes and critical risks. In the absence of the necessary genuine understanding of respective system dynamics, the dominating unitary approach tries the obvious and empirically motivated *protective* kind of strategy, with growing mechanical restrictions on the emerging changes and their assumed causes, thus *inevitably limiting progressive development* (turning then into degradation), but also introducing unpredictable and unexpected changes of any (but most probably negative) kind. The accepted unitary strategy of risk mitigation leads thus inevitably to growing, maybe even more dangerous risks, and in general to the growth of the *most dangerous risk of advancing global degradation*.

We arrive here at the *fundamental origin* of unitary approach deficiency, which fails to see the *omnipresent dynamic instability* of *any* real, dynamically multivalued interaction process and system evolution [11-19]. In this sense the dominating unitary, dynamically single-valued theory and approach cannot provide the correct, causal understanding of progress either, replacing it with inconsistent, empirically driven and vague ideas about "good" (progressive) and "bad" (destructive) changes. Our unreduced interaction analysis shows that the desired "stability" of any real system opposed to "crisis" and other "risks" is nothing but its *permanent progressive changes* of entropy-complexity growth (or *sustainability* thus rigorously defined) based on the *intrinsic dynamic instability* of real, *multivalued* interaction dynamics and related *dynamically random* changes. Therefore our universal principle of complex-dynamical control [11-19] emphasizes the *optimal growth of entropy-complexity* realised by the *dynamically random* changes, instead of the false unitary control strategy of mechanistic restrictions in order to preserve the desired (external and illusive) regularity and status quo.

Based on our universal complexity development paradigm [11-19], with the discrete transformation of latent action-complexity $\mathcal{A}(x,t)$ (dynamic information) to the explicit form of entropy-complexity $S(x,t)$ (dynamic entropy), $\Delta S(x,t)=-\Delta\mathcal{A}(x,t)>0$, we can propose the *universal definition* of "undesired", negative instability kind referred to as *risk* in the form of increased (maximum) probability of destructive entropy-complexity growth ("the death branch" on the universal complexity evolution curve [15,18,19]), with the quantitative *risk magnitude*, *R*, equal (eventually up to a coefficient) to the reciprocal entropy-complexity growth rate, or reciprocal generalised energy *E*:

$$R=\left(\frac{\Delta S}{\Delta t}\Big|_{x=\text{const}}\right)^{-1}=\left(-\frac{\Delta\mathcal{A}}{\Delta t}\Big|_{x=\text{const}}\right)^{-1}=\frac{1}{E};\ \frac{\tau}{\mathcal{A}_0}, \tag{1}$$

with the opposite *sustainability magnitude*, $\mathcal{G}=1/R$, coinciding (again up to a coefficient) with the total (development) energy *E*:

$$\mathcal{G}=\frac{1}{R}=\frac{\Delta S}{\Delta t}\Big|_{x=\text{const}}=-\frac{\Delta\mathcal{A}}{\Delta t}\Big|_{x=\text{const}}=E;\ \frac{\mathcal{A}_0}{\tau}, \tag{2}$$

where $\mathcal{A}_0$ and τ are the characteristic values of action-complexity magnitude (or variation) and change period respectively.

Since the generalised total energy characterises the temporal rate of action-complexity transformation to entropy-complexity, i. e. actually the *rate of progress*, it is natural that the positive, progress-bringing result of universally unstable multivalued dynamics, or sustainability $\mathcal{G}$, is proportional to the rate of progress, while the negative result of the same omnipresent instability, in the form of degradation probability, or risk *R*, is inversely proportional to the same progress rate *E*, so that $R\mathcal{G}=1$. The risk magnitude *R* is high (on any scale) during stages of weak entropy-complexity growth (between its stepwise transition jumps) and especially during and after the fatal transition to the death branch of slow, destructive entropy growth, while it is minimal during rapid system transitions to higher complexity sublevels. Correspondingly, all risks will grow with slowing down (higher τ) of transformation of smaller amounts of action-complexity $\mathcal{A}_0$, eq. (1).

It is important that the unified dynamic complexity and its growth rate of the above risk definition emerge from the *unreduced, multivalued interaction dynamics* [11-19] taking the form of permanent probabilistic change of incompatible system realisations and thus including the *totality* of occurring, dynamically random events. The obtained *unified* risk magnitude definition of eq. (1) shows that the truly reliable (and actually universal) way of risk reduction can only be based on *sustainable, intrinsically progressive complexity development* liberated from inevitable crises and impasses of unitary kind of organisation. While the definite transition to that genuine sustainability regime of intrinsically low risks occurs only as a transition to the superior complexity level of Harmonical System [11,14,15,18.19], the proposed universal risk definition and criterion can be useful also at lower complexity levels.

Whereas the main way of risk reduction (in particular in economy and finance) is the search for further *progressive growth of unreduced entropy-complexity*, in accord with the underlying universal symmetry of complexity, $\Delta S(x,t)=-\Delta\mathcal{A}(x,t)>0$, the *unreduced* complex dynamics analysis at a given complexity sublevel (for example during phases of slow complexity growth) also provides universal understanding of the origin of risky events and ways of their probability reduction. We can see, in particular, that any “stable”, low-risk system operation mode corresponds to the unified *SOC regime* of internal-

ly chaotic, but externally quasi-regular complex dynamics [11-19], while the opposite limiting regime of *global chaos* implies maximum risk values. Recalling the *unified criterion of global (or partial) chaos regime* in terms of major frequency *resonances* between system operation modes, we arrive at the rigorously specified conclusion that in order to reduce the risk probability, *one should avoid frequency, or temporal, resonances* between major repeated operations involving essential quantities of money or other exchange matter, i. e. one should avoid the condition $m\omega_Q \cong n\omega_\xi$, where *m*, *n* are small integers and ω_Q, ω_ξ are major system operation frequencies involving essential exchanges. While in a number of cases respective rules are practically implemented based on intuitively felt empirical considerations and experience, we provide the *universal and rigorously substantiated criterion* in terms of any unreduced interaction dynamics.

Moreover, for situations with relatively smooth complexity transformation we can apply our unified Hamilton-Schrödinger formalism [11-19] in order to describe the inhomogeneous, highly nonlinear and chaotic *dynamics*, *distribution* and *evolution* of the introduced risk magnitude *R* (eq. (1)). Consider, for example, an often suitable form of the generalised Hamilton-Jacobi equation describing the unreduced dynamics of action-complexity $\mathcal{A}(X,t)$:

$$\frac{\partial \mathcal{A}}{\partial t}+\sum_{i=1}^{N}\left\{\frac{1}{2m_i}\left(\frac{\partial \mathcal{A}}{\partial x_i}\right)^2+\left[U_i\left(x_i,t\right)+\sum_{j=1,\,j\neq i}^{N}V_{ij}\left(x_i,x_j\right)\right]\mathcal{A}\left(X,t\right)\right\}=0, \qquad (3)$$

where $X=(x_1,x_2,...,x_n)$ is the vector of all relevant agent coordinates x_i (configuration measures), $U_i(x_i,t)$ is the generally time-dependent external influence potential acting on the *i*-th agent with the generalised mass m_i, $V_{ij}(x_i,x_j)$ is the potential of interaction between the *i*-th and *j*-th agents, and *N* is the total number of agents (maybe hierarchically organised). Using our unreduced interaction analysis with the help of the generalised EP formalism [11-19], we can find its complete, dynamically multivalued, or suitable approximate solution for action-complexity $\mathcal{A}(X,t)$ and then using eq. (1) find the corresponding, in general also multivalued, risk distribution and evolution in time and space of relevant (financial, economic, technological, social, or political) variables, $R(X,t)=-(\partial\mathcal{A}/\partial t)^{-1}$. This approach opens absolutely new, mathematical-

ly exact and causally substantiated possibilities for the totally objective analysis of risk dynamics and evolution in arbitrary real system at any level of its (growing) complexity.

As shown in refs. [11,15,18-20], further progressive entropy-complexity growth of the global civilisation system towards lower-risk dynamics is actually possible today only by a step-like transition to the superior complexity level corresponding to vanishing risk values, with the single alternative of destructive, death-branch complexity evolution realising the opposite tendency of essentially growing risks. Today we have therefore the nontrivial, historically significant bifurcation point leading to that qualitatively big and always growing difference between the near-future low-risk and high-risk levels and evolution tendencies. Using our universal complexity laws realising the unified symmetry of complexity [11-19], we can specify major features of the desired superior-complexity level of development also referred to as the Harmonical System, or genuine sustainability [11,15,18,19]. Based on the clear, explicit understanding of the unreduced complex dynamics of the entire planet system, those features include the new, *emergent kind of social structure* and corresponding *intrinsically progressive, reason-based governance*, *creative (complexity-increasing) production ways and processes*, *new kind of settlement, infrastructure and lifestyle*, and certainly *new organisation, content and role of the intrinsically complete knowledge* of (growing) unreduced dynamic complexity.

The *qualitatively new, reason-based (global) governance system* [20] deserves a special mention here as the concrete and indispensable element to be introduced in addition to (and then increasingly instead of) traditional, unitary governance. In accord with the universal complexity correspondence principle, it appears in this higher-complexity tendency as a *superior governance structure* oriented to *explicit, rigorously substantiated and clearly presented problem solutions*, which need not immediately replace the existing, unitary governance structures preserving their full decision power. Now, however, these traditional governments and populations they govern are provided with the consistently substantiated and openly presented guidelines of those real problem solutions in the spirit of intrinsically progressive complexity growth. And although they are not formally obligatory for realisation, they clearly

demonstrate the extended possibilities of intrinsically progressive complexity development.

We obtain thus the superior-complexity level of (unified) *social conscious intelligence* of the planetary "organism" (including all its interactive and omnipresent global networks), which is absent in the known traditional social structures relying only on the empirical, "animal" and very short-sighted kind of general intelligence. However, that traditional "spontaneous", "invisible-hand" kind of development of social structure is now totally exhausted at the attained high level of "globalised" civilisation complexity, which can further progress only with the help of explicit social consciousness layer, providing also the *advanced, superior-complexity version of traditional unitary democracy* (usually erroneously considered to be the best possible one, within its own paradigm). This superior-complexity, explicitly conscious democratic system is not limited in its intrinsically progressive, low-risk development and provides its ever growing, creative liberties due to the qualitatively extended, causally complete kind of knowledge and the new system of science of unreduced dynamic complexity [11-19].

References

[1] *Challenges of a Changing Earth*, Proceedings of the Global Change Open Science Conference, Amsterdam, 10–13 July 2001, Eds. W. Steffen, J. Jäger, D. J. Carson, and C. Bradshaw (Springer, Berlin Heidelberg New York, 2002).

[2] M. Rees, *Our final hour: A scientist's warning: How terror, error, and environmental disaster threaten humankind's future in this century—on earth and beyond* (Basic Books, New York, 2003).

[3] *The Future of Life and the Future of Our Civilisation*, Ed. V. Burdyuzha (Springer, Dordrecht, 2006).

[4] L. Szombatfalvy, *The Greatest Challenges of Our Time* (Ekerlids, 2010). https://api.globalchallenges.org/static/files/the-greatest-challenges-of-our-time.pdf.

[5] *Global Catastrophic Risks 2017*, Ed. J. Leyre (Global Challenges Foundation, 2017). https://api.globalchallenges.org/static/files/Global%20Catastrophic%20Risks%202017.pdf.

[6] A. Toffler, *Future shock* (Bantam, New York, 1984).

[7] Vernor Vinge, "The Coming Technological Singularity: How to Survive in the Post-Human Era", originally in *Vision-21: Interdisciplinary Science and Engineering in the Era of Cyberspace*, Ed. G. A. Landis, NASA Publication CP-10129 (1993), p. 11. http://mindstalk.net/vinge/vinge-sing.html.

[8] S. Battiston, J. Doyne Farmer, A. Flache, D. Garlaschelli, A. G. Haldane, H. Heesterbeek, C. Hommes, C. Jaeger, R. May, and M. Scheffer, "Complexity theory and financial regulation", *Nature* **351** (2016) 818.

[9] A. Sergueiva, "Systemic Risk Identification, Modelling, Analysis, and Monitoring: An Integrated Approach", *arXiv:1310.6486* (2017).

[10] F. Caccioli, P. Barucca, and Teruyoshi Kobayashi, "Network models of financial systemic risk: a review", *Journal of Computational Social Science* **1** (2018) 81. Arxiv:1710.11512.

[11] A. P. Kirilyuk, *Universal Concept of Complexity by the Dynamic Redundance Paradigm: Causal Randomness, Complete Wave Mechanics, and the Ultimate Unification of Knowledge* (Naukova Dumka, Kyiv, 1997). ArXiv:physics/9806002.

[12] A. P. Kirilyuk, "Universal Science of Complexity: Consistent Understanding of Ecological, Living and Intelligent System Dynamics", *ArXiv:0706.3219* (2007). Russian version: *Nanosystems, Nanomaterials, Nanotechnologies* **11** (2013) 679.

[13] A. P. Kirilyuk, *Complex Dynamics of Real Quantum, Classical and Hybrid Micro-Machines* (LAP LAMBERT Academic Publishing, Saarbrücken, 2013). ArXiv:physics/0211071.

[14] A. P. Kirilyuk, *Complex-Dynamic Origin of Consciousness and Sustainability Transition* (LAP LAMBERT Academic Publishing, Saarbrücken, 2014). ArXiv:physics/0409140.

[15] A. P. Kirilyuk, *Theory of Everything, Ultimate Reality and the End of Humanity: Extended Sustainability by the Universal Science of Complexity* (LAP LAMBERT Academic Publishing, Beau Bassin, 2017).

[16] A. P. Kirilyuk, "Unreduced Dynamic Complexity: Towards the Unified Science of Intelligent Communication Networks and Software", In: *IFIP, Vol. 229, Network Control and Engineering for QoS, Security, and Mobility, IV*, ed. by D. Gaïti (Springer, Boston, 2007), p. 1. ArXiv:physics/0603132.

[17] A.P. Kirilyuk, "New Mathematics of Complexity and Its Biomedical Applications", *Banach Center Publications* **109** (2016) 57. Hal-01147395.

[18] A.P. Kirilyuk, "Towards Sustainable Future by Transition to the Next Level Civilisation", In: *The Future of Life and the Future of Our Civilisation*, Ed. V. Burdyuzha (Springer, Dordrecht, 2006), p. 411. ArXiv:physics/0509234.

[19] A. P. Kirilyuk, "Dynamic Origin of Evolution and Social Transformation", *Nanosystems, Nanomaterials, Nanotechnologies* **11** (2013) 1. ArXiv:1212.1939.

[20] A. P. Kirilyuk, "Sustainable Reason-Based Governance after the Globalisation Complexity Threshold", work submitted for the Global Challenges Prize 2017, *hal-01736865* (2018).