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# NATIONAL FINANCIAL SYSTEM ANALYSIS IN TERMS OF THE COMPLEX SYSTEMS THEORY

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**ABSTRACT**

The recession caused by the pandemic and the vulnerabilities faced by the entire international monetary system and the national financial systems requires a particular approach to analyzing the current situation and the design of new developments. Based on these arguments, we set out to investigate national financial systems from the perspective of complex systems theory.

Following the research, we concluded that understanding the nature and characteristics of the manifestation of synergistic effects allows organizing the financial system's management at a new quality level, based on the concepts of discretion and stability of development trajectories of the world economy.

**Introduction.** The history of man's development and formation as a social being - is a complex search, dimensioned over centuries, of ways and mechanisms to consolidate his socialization elements in the form of written and unwritten rules, laws, norms, societies, systems.

The scenario of the historical process can be presented as a system of challenges and answers. The problems accumulated in front of society seek its solution, which is therefore discovered in one form or another. From this moment, the evolution changes its direction and, thus, instead of the canceled problems, new ones appear. Therefore, the answer to any of the historical challenges means stopping the transformations: each of the solved problems leads to the emergence of new challenges, often more fundamental and more complicated than the previous ones.

The dynamics of life, the defiance imposed by risk and uncertainty, demand society a new creative effort likely to lead to the reconstruction and recapture of the notion of progress. There is no real human culture other than the one that can be encountered creation process in the real-life context, in the production and continuous testing of each of our many efforts and the image of the future model ourselves.

Moreover, the history of ideas, utopia, and philosophy is closely linked to the history of facts of all kinds, especially to the history of economic development.

After long and contradictory searches, the science of the twentieth century synthesized the scientific category of system. It has given the possibility to both theory and practice to go beyond the simplistic understanding of reality and to direct man to rethink the way of organizing and carrying out his social, economic, political activity. [1]

The theory, which deals with the study of interrelationships within existence, reveals the types of relationships specific to phenomena, deciphering functions, dysfunctions, the ends of some processes, and the theory of complex systems.

According to the mentioned theory, a system is the totality of interdependent elements. The components of the system are called its elements until they have a relationship with this system. The interconnection of the elements of the system determines its integrity. Moreover, if an element of the system loses its connection with the system, it turns into a new system. Like the other part of the

system, which turns into another new system, all systems have their elements. Analogously and all social systems are composed of elements.

**Purpose of the study.** This publication aims to analyze the national financial system by the approaching of the theory of complex systems.

**Literature review.** The research of economic systems brings us closer to a deeper understanding of the contemporary economy's functioning basics. The inevitable technical-scientific progress generates new "high" technologies, information sub-branches, and "new" qualitative financial markets.

The systemic category of generalization of financial activity appears in the form of a financial system with safe possibilities to regulate the system's activities, influencing the national economy and, therefore, society.

Knowledge of the financial system's content aspect must logically start from Systems Theory and its concepts related to the system category. The systemic approach allows a quantitative and qualitative analysis of the financial system's development and functioning, based on its nature and specificity, which inclines us to use the concept of synergy and chaos theory in research.

Synergy is often called "the science of the complicated," the teaching of self-organization and the universal laws of the evolution of complex dynamic systems. It is currently considered one of the most popular and promising interdisciplinary approaches. One of the founders of synergy, the German physicist H. Haken, determined it not only as of the science of self-organization but also as the theory of "the common action of several subsystems, as a result of which a new structure appears at the macroscopic level." [2] He proposed this theory be studied in a new discipline, called synergy, which originates from the Greek word "synergeia", which in translation means "common coordinated action". According to Haken, synergy has two meanings: on the one hand, the joint action of the elements of the composite system, and on the other hand - the cooperation of scientists from different fields. [3]. At the beginning of the 80s of the last century, the science of self-organization was called synergy in Germany (H. Haken), in French-speaking countries - the theory of dissipative structures (I. Prigogine) and in the USA - the theory of dynamic chaos (M. Feigenbaum). In the literature, these "branches" of self-organization science are also called "*complex science*."

Synergy has emerged at the intersection of various scientific schools. As a result, synergy has increasingly begun to influence different areas of activity and increase interest. Unlike traditional scientific knowledge fields, synergy studies the laws of the evolution of systems of any kind. Ignoring the specific nature of systems, synergy acquires the ability to describe systems' evolution in an accessible way. This allows synergy to be considered an easy-to-understand field for science representatives from a completely different field. [4] This approach is currently an area of interest for different people - from students to politicians, from managers to researchers. [5]

Another 25 years ago, one of the most well-known researchers in the field of synergy, I. Danilov, characterized this current, related to the research of nonlinear dynamic systems as follows: "Among the many scientific titles that scientific progress has brought to our century" the century of nonlinearity" is one of the least resounding, but more significant and well deserved... The world of nonlinear functions, like nonlinear phenomena, frightens, conquers, and irresistibly tempts through infinite diversity. There is no room for decent standards here, here the variability and range of forms govern." [6]

The systems that constitute the study's object of study can be of a quite varied nature and studied by different sciences, such as physics, chemistry, biology, mathematics, economics, and sociology. [7]

In this context, the arguments of researchers K. Mathews, M. White, R. Long regarding the application of synergy in the social sciences are of interest. Recognizing the usefulness of traditional methods - linear methods - in the social sciences, she remarks that there is no apparent reason why human behavior should be more linear than the behavior of other living and non-living systems. [8] At the same time, arguing with skeptics who consider "complex science" a conjectural science, a popular current "bandwagon science," distinguish several arguments in defense of the thesis on the perspective of using chaos theory in researching social processes, namely:

- Increasing the pace of changes in economic processes. Often these changes are unpredictable and can lead to unexpected results; the dynamics of social systems contain an increasing share of uncertainty, includes periods of chaotic behavior and demonstrates variants characteristic of fractal features (typical example - the dynamics of financial markets);

- The similarity of the most critical aspects of the development of economic systems, according to a series of researchers, with natural systems: the non-linear dynamic correlation between

many components; complicated interdependence between components; the possibility of dynamic development in compound forms, including chaotic regimes and self-organization;

- The similarity of the mathematical models that give rise to the chaotic behavior in physics or biology with some elaborated in the research process of social processes;

- Disappointment with the results obtained from empirical research based on standard statistical methods (usually linear) due to the omission of some essential variables in the research program; evaluations.

In economics, chaos theory came into view in researchers, especially after the stock market crash of October 1987.

**Materials and Methods.** In the contemporary scientific literature, the evolutionary-synergistic paradigm is often launched at the forefront of science. Following this paradigm, development is understood as the succession of long periods, corresponding to a stable state of the system, interrupted by short periods of chaotic behavior (bifurcations), after which the transition to another stable state occurs (attractor), the choice of which is usually determined by the fluctuations at the bifurcation point. For a clearer understanding of the attractor's notion, it is often represented in a geometric shape in space, the size of which coincides with the number of variables needed to describe the evolution of the system over time fully. Each system has its variables, different from others. In any case, the development of systems in time in given initial conditions is described by the trajectory from the initial state to the final one, i.e., by the attractor.

The attractor can be represented in the form of a trajectory and a surface or sphere figure. In the 1980s, so-called foreign attractors were revealed, which are characterized by fractional size. Strange attractors are fractals.

According to H. Bourguinat (1992) in chaos theory, even if we work with non-linear equations, which turn and move in a maze whose appearance changes with each step, as the order or degree of these equations changes the idea always remains attractive, especially for the financial field [9].

A point in an abstract space represents the state of all dynamic systems - the phase space - called the attractor, to which the state of the system tends. This is a geometric shape - sometimes too complex - that corresponds to the trajectory that describes the system until it is stable or has a limited trajectory to which it tends. There are two categories of attractors: predictable attractors (well behaved), for which a small change in the initial conditions is limited in trajectory as it advances in time (pendulum motion); the second category is that of foreign attractors, which result from almost indistinguishable trajectories and which mix in the phase space. The evolution of the system is never the same in this case. If the trajectories are convergent, they will be steady due to small perturbations. Otherwise, chaos will ensue.

From a mathematical point of view, a more precise definition of chaos is as follows: [10]

Any $\Omega$ space equipped with a metric (with a metric) $d$ with $f$: $f$: $\Omega \rightarrow \Omega$, or a continuous function from $\Omega$ to $\Omega$.

The discrete dynamical system ($\Omega$, $f$) if there is $\delta > 0$, o that for all w and all $w \in \Omega$ and al $\varepsilon > 0$here is a $w' \in \Omega$ and a $k$ that:

d$(w, w') < \varepsilon$ and d$(f^k w, f^k w') \geq \delta$

with $f^k w$, which represents $k$- or iterations from point $w$ to the function $f$.

Another way to observe whether the trajectories are convergent or separate in time is by using the Lyapunov exponent.

From $X_t^M$ (t=1,2, …., T) the pairs ($X_i^M, X_j^M$) are chosen so that:

$$r_s(M, i, j) = \| X_i^M - X_j^M \| < \varepsilon$$

With $\varepsilon$ a small positive number and $\|.\|$ a metric $X_i^M$ and $X_j^M$ they are close to each other.

It is then calculated:

$$r_s(M; i, j) = \| X_{i+n}^M - X_{j+n}^M \|$$

By adopting the report:

$$d_n(M; i, j) = r_n(M; i, j) / r_0(M; i, j)$$

By aggregation:

$$L(M, n) = \sum_{i \neq j} Log d_n(M; i, j) / N(N-1)$$

If the neighboring points differ $d_n(M;i,j)$, then they should be larger than one unit. The system will be stable if L(M, $n$) <0. For classical systems, it is expected that L(M, $n$) >0.

In conclusion, according to Bourguinat, while the share of what cannot be transposed from the natural sciences to human behavior is quite imposing, the approach from the perspective of chaos theory seems useful to understand how at some point, the financial system is likely to be disrupted.

The COVID19 pandemic was for the entire international financial system and the national financial systems a destabilizing factor in their evolution.

**Results and discussion.**

The global economic crisis, caused by the COVID-19 pandemic, which can be seen as a bifurcation, from the perspective of complex systems theory has caused deficiencies in both the international monetary system and national financial systems. The Republic of Moldova, being a small country with an open economy, was affected by this crisis quite hard. The pandemic's economic effects are transmitted to the economic activity and, therefore, to the Republic of Moldova's financial system through several channels simultaneously, divided into external and internal.

The *channel of international financing* may spread risks related to difficulties in financing the Republic of Moldova's economy due to uncertain financial conditions in the global economy.

The economy of the Republic of Moldova has to survive with a small capital inflow because the external environment is also under pressure from the health crisis caused by the COVID 19. pandemic tended to diminish. It should be mentioned that the capital inflow in the Republic of Moldova registered a decreasing trend, starting with 2017 and the GDP growth had the same direction. Thus, the COVID 19 pandemic's negative consequences intensified against the background of the negative trends of the inflows of international flows in the Republic of Moldova during the years 2017-2019.

**The foreign trade channel** transmits risks related to the economic situation of the main economic partners of the country, where negative changes in GDP were registered. Vulnerabilities in the economies of the trading partners of the Republic of Moldova will undoubtedly influence the slowdown in exports of goods and services (according to official data in January-September 2020 / January-September 2019, exports accounted for 86.6% and imports 89.7 %)[1] and they will therefore lead to a deterioration of the external balance.
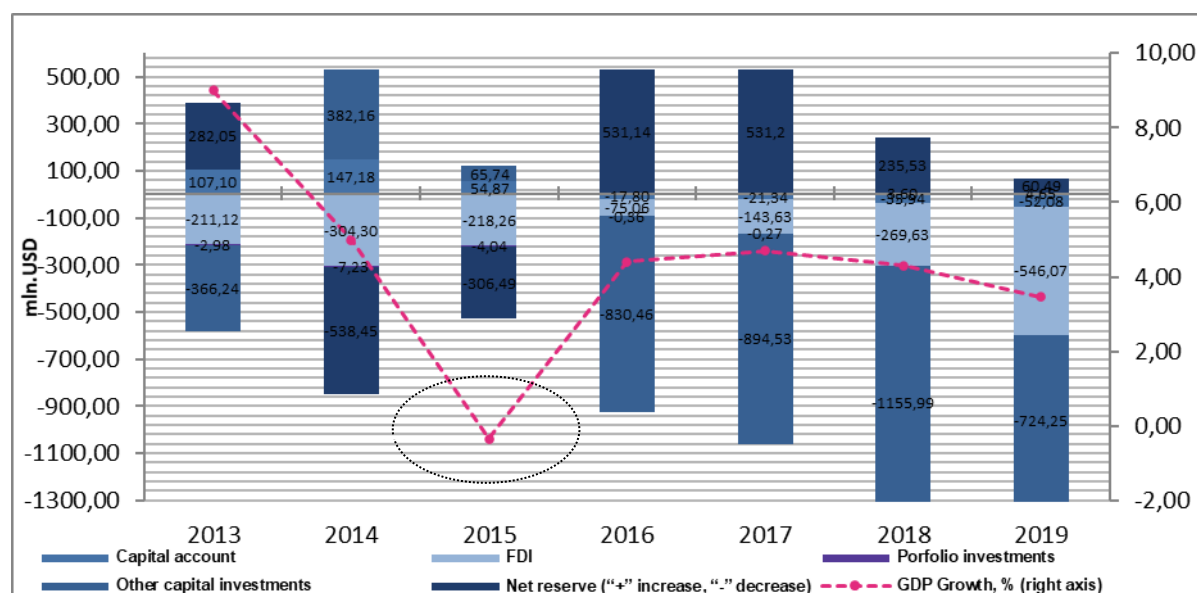


*Fig. 1. Dynamics and structure of net capital flows in the Republic of Moldova*
*Source: [11].*

The pandemic's onset hurts the revenues of all sectors of the economy (non-financial corporations, the financial industry), the population, and the state. As a result, we can highlight a next (internal) channel for spreading risk in the Republic of Moldova's economy, namely *the revenue*

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[1]National Bureau of Statistics. External trade [online]. Retrieved from
https://statistica.gov.md/category.php?l=ro&idc=336&https://statistica.gov.md/category.php?l=ro&idc=336&

*channel*. The most significant internal factor of the pandemic's negative impact on the Moldovan economy was the need to stop production activities from reducing the burden on the health system and ensuring the population's health and epidemiological well-being. Thus, the companies did not obtain income that they could have had under normal economic activity conditions. Several organizations that continued to operate recorded declines in activity and consequently in revenues as part of the revenue channel, the negative impact of the COVID 19 pandemic and the restrictions adopted against it affect, as mentioned, the entire value chain and affect the full range of entities involved in production activities. This means that revenue losses occur not only for a particular enterprise but also for its employees, suppliers, contractors and service providers, budgetary authorities and non-budgetary funds, financial organizations whose customers are the enterprise and its employees.

Another internal channel that can have a negative impact is *the credit channel*. A decrease in the income of economic entities reduces their solvency, which may limit banks' willingness to continue lending to the economy. The credit channel can be triggered as a result of a series of risks: the decrease of the incomes of the potential debtors, who will have to withdraw their own "credit cravings," due to the narrowing of the credit service possibilities, in the conditions of significant uncertainties of income recovery citizens and companies in the future; deterioration of credit quality of borrowers and an increase in credit risk. Taken together, the above factors form the conditions for limiting lending activity, which in turn can become a factor in the deterioration of the economic situation, as restricting access to finance does not allow economic entities to maintain the same level of production activity. As a result, a feedback effect may occur: a decrease in economic activity triggers a credit contraction, which further suppresses economic activity. However, it should be noted that this situation is not currently characteristic of the Republic of Moldova, but it cannot be ruled out in the context of a new wave of the COVID 19.

Debt is needed for growth, and countries with low levels of private debt to GDP are well-positioned for healthy growth, leading to an increase in the share (role) of the private sector in the national economy GDP.
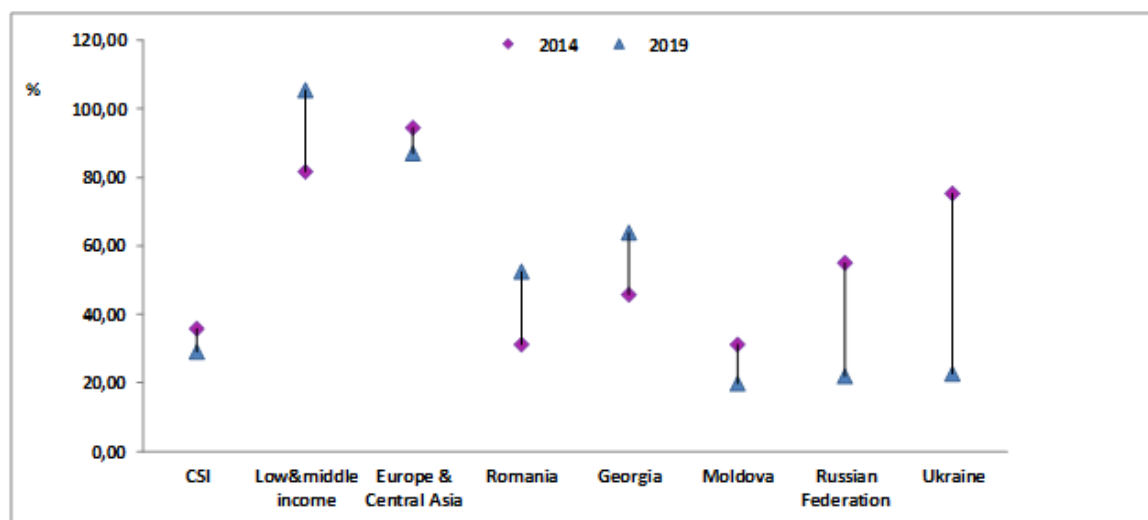


*Fig. 2. Domestic credit to private sector (% of GDP), comparison*
*Source: [12].*

The indicator of private sector debt to GDP has a double interpretation. On the one hand, it is one of the indicators or signs (but not the only one) of economic development and prosperity. The higher value of the indicator, the greater the private sector funding in a country and thus the greater opportunities and space for the private sector to develop and growth in a country and thus the greater the opportunities and space for the private sector to develop and grow. Increasing the private sector's role in the national economy will generate a higher level of development of the country's economy. In general, this is an essential indicator of the degree of economic development and success (but not the only one) because it demonstrates the private sector's ability to work hand in hand with the public or government sector.
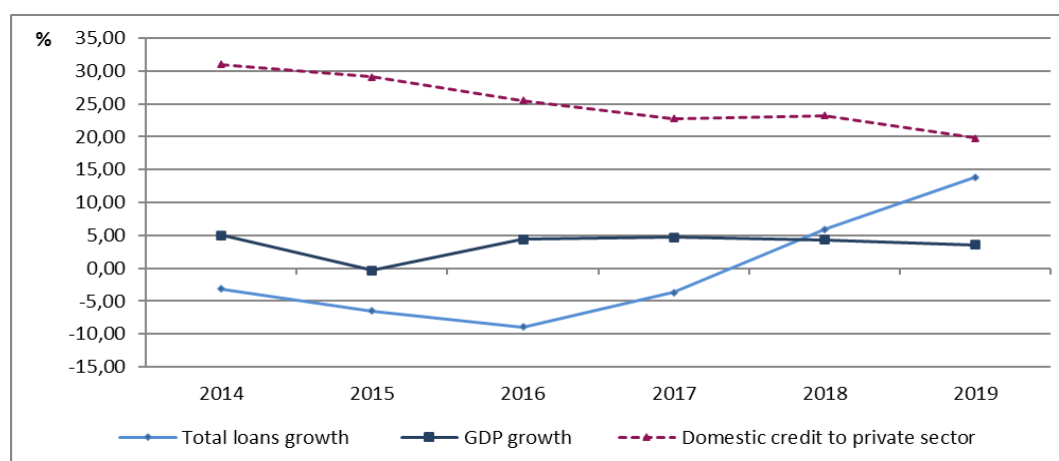
*Fig. 3. Credit-to-GDP ratio gap*
*Source: [13].*

And on the other hand, high indebtedness can be an aggregate vulnerability for national financial systems. Another problem it brings is much more subtle and insidious: when it is too large, private debt becomes an obstacle to economic growth.

In the Republic of Moldova's current economy, following the exogenous shock caused by the pandemic crisis, our country's economy will contract, which will affect the financial system. Usually, in such situations, banks reduce loan supply due to expectations of receiving potential losses. In turn, this further slows down economic activity and repeats the negative spiral.

However, the ratio of private-sector loans to GDP still has reservations (fig. 2). At the same time, the growth of loans compared to the growth of nominal GDP is high in the current period; therefore, the ratio of loans to GDP is higher than the trend (fig.3).

This effect can lead to a significant increase in the debt burden of households and the corporate sector. However, as the economy recovers, the gap is expected to close gradually, and the ratio of lending to GDP to approach the long-term trend.

The gradual downward trend in the share of business loans in total loans has manifested itself over the last six years.

Following the outbreak of the COVID 19 pandemic, our country's situation is a dramatic one both at the human and economic level. The situation in the Republic of Moldova is much worse because the health crisis has overlapped against an unfavorable background of domestic economic development. The difficulty of assessing the impact of the COVID-19 virus on the economy is due to the existing shock's particularity. COVID-19, in essence, is a purely exogenous shock to the economy, which has a significant negative impact on both demand and supply.

Therefore, the analysis of the current situation from the perspective of overcoming the economic crisis requires a particular approach, which can be the theory of complex systems.

**Conclusions.**

The use of the synergistic methodology in economic research is now becoming more widespread, as it allows, compared to other earlier approaches, to detect irregular effects in economic realities while allowing understanding the nature of their occurrence better, to identify and identify an appropriate way to influence the course of economic processes. Understanding the nature and characteristics of the manifestation of synergistic effects allows the management organization of the financial system at a new qualitative level, based on the concepts of discretion and stability of the world economy's development trajectories. The presence of synergistic effects in the world-financial phenomenon requires new approaches in forecasting, planning, and management at different levels - from national economies to the international monetary system.

The research of the synergistic manifestation particularities effects both in the international monetary system and in the financial systems will allow a more in-depth analysis of the factors of the negative influence that can be considered as an obstacle of the transition of the national economy to:

 – an innovative way of development;
 – understanding the specifics of economic cyclicality caused by its synergistic nature;
 – development of a theoretical basis for the formulation of economic policies aimed at financial stability.

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