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MONETARY PROCESSES PECULIARITIES DURING THE CRISIS IN UKRAINE AND ADJUSTMENT OF MONETARY POLICY

Abstract. The purpose of the article is to determine the monetary processes peculiarities during the crisis period of economic development and areas of monetary policy adjustment. The article presents the results of the main monetary indicators of Ukraine for 2005—2020 dynamics regularities assessment. The cyclic nature of their dynamics with a cycle length of 12 months, an increase cyclical swing range and the level of «white noise» of random deviations from the cyclic dynamics line are confirmed. Entropy and entropy production are calculated for the main monetary indicators. The hypothesis that the monetary indicators dynamics uncertainty is determined by the uncertainty of the «white noise» of their random deviations from the lines of cyclic dynamics based on the calculation of the entropies of the dynamics and the dynamics of entropies is put forward and confirmed. Three groups of monetary indicators are formed according to the level of uncertainty in them. According to the research results, the monetary sphere of Ukraine dissipation was stated during the whole period of 2005—2020 with increase of its rates in time intervals, which preceded the crisis phenomena aggravation (07.2007—07.2008, 03.2013—01.2014, 01.2020—06.2020). The sources of uncertainty in the monetary sphere are identified: the amount of cash due to «cash — M0» with 5.4 months lag and the amount of cash due to «cash — M3» with 7.8 months lag. Based on the results of relations between monetary indicators analysis, the directions of monetary policy for overcoming the crisis phenomena in the monetary sphere of Ukraine are proposed. In particular, it is appropriate to change the restrictive monetary policy to an expansionary one, taking into account the lag of action in the relations between entropies / entropies production of the main monetary indicators.The obtained results can be of practical importance in the system of state regulation to stimulate monetary circulation not only in crisis but also in post-crisis periods, ensuring key monetary indicators long-term stability and monetary policy effectiveness improving.

Keywords: monetary indicators, monetary aggregates, uncertainty, entropy, entropy production, dissipation, regulation, monetary policy.

JEL Classification E50, E51, E52

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ОСОБЛИВОСТІ МОНЕТАРНИХ ПРОЦЕСІВ У КРИЗОВИЙ ПЕРІОД В УКРАЇНІ ТА КОРИГУВАННЯ МОНЕТАРНОЇ ПОЛІТИКИ

Анотація. Метою статті є визначення особливостей монетарних процесів у кризовий період розвитку економіки і напрямів коригування монетарної політики. Наведено результати оцінки закономірностей динаміки основних монетарних показників України за 2005—2020 рр. Підтверджено циклічний характер їхньої динаміки з довжиною циклу 12 місяців, збільшення діапазону циклічних коливань і рівня «білого шуму» випадкових відхилень від лінії циклічної динаміки. Розраховано ентропію і виробництво ентропії для основних монетарних показників. Висунуто і підтверджено гіпотезу, що невизначеність динаміки монетарних показників визначається невизначеністю «білого шуму» їхніх випадкових відхилень від ліній циклічної динаміки на основі розрахунку ентропій динаміки і динаміки ентропій. Сформовано три групи монетарних показників за рівнем невизначеності в них. За результатами дослідження констатована дисипація монетарної сфери України протягом усього періоду 2005—2020 рр. з посиленням її темпів у часові інтервали, що передували загостренню кризових явищ (07.2007—07.2008, 03.2013—01.2014, 01.2020—06.2020). Визначено джерела невизначеності процесів у монетарній сфері: обсяг готівкових коштів у зв'язку «*готівка* $\leftrightarrow M0$» із лагом 5,4 місяця та обсяг готівкових коштів у зв'язку «*готівка* $\leftrightarrow M3$» із лагом 7,8 місяця. За результатами аналізу системи зв'язків між монетарними показниками запропоновано напрями монетарної політики для подолання кризових явищ у монетарній сфері України. Зокрема, доцільною визнана зміна рестрикційної монетарної політики на експансіоністську з урахуванням лагу дії у зв'язках між ентропіями / виробництвом ентропій основних монетарних показників. Отримані результати можуть мати практичне значення в системі державного регулювання для стимулювання грошового обігу не тільки у кризові, а й у посткризові періоди, забезпечуючи довгострокову стабільність ключових монетарних показників і поліпшення ефективності монетарної політики.

Ключові слова: монетарні показники, грошові агрегати, невизначеність, ентропія, виробництво ентропії, дисипація, регулювання, монетарна політика.

Формул: 1; рис.: 3; табл.: 2; бібл.: 25.

Introduction. Justification of directions, methods and tools for regulating economic development has become one of the most pressing tasks of modern economics. In addition to the growing number of challenges and threats, including civilization alones, which cause instability in various national economies in particular and in the world economy ingeneral, the number of so-called «blackswans» has increased, causing destructive effects on economic development. Crises of a cyclical nature have been significantly deepening by socio-political factors, military aggression, and by global nature incidents. One of the lasts ignificant negative impacts was the global COVID-19 pandemic. According to some estimates, Ukraine's economic losses in 2020 were projected at 10% of GDP [1], and world GDP losses — at 5% [2]. With such an intensity of local and global crises, the choice of crisis management tools, determining the exact and most effective moment of their application and performance evaluation becomes especially important. Quite often economic development regulation tools tested in the developed countries are not effective innational economies of other level of development. Moreover, their use often leads to the crisis situation worsening and is not justified in terms of resources availability.

As a rule, crisis situations require monetary policy adjustments in the state regulation system, as they are accompanied by instability of monetary processes, high inflation, declining effective demand, local crises in the money and capital markets. The use of monetary regulation, therefore, is a necessary way to stabilize the economy, reduce destructive phenomena and promote further economic growth

Recent research analysys and problem setting. A significant number of scientific works are devoted to the substantiation of theoretical, methodological and methodological-practical principles of using monetary policy to regulate the country's economy development direction. There is a difference in the understanding of the monetary policy essence both interms of its content and the object and monetary instruments use direction. For example, E. Dolan, et. al. [3, p. 38] defines the main purpose of monetary policy to regulate the quantitative indicators of the money supply that is currently incirculation; V. Stelmakh, et. al. [4, p. 58] — money market regulation; O. Krylova [5, p. 25] — national currency stability ensuring, curbing inflation, economic growth ensuring; I. Vietrova [6, p. 170] identifies the main goal of monetary policy — among other things — public demand for money ensuring; P.Arestis and M. Sawyer [7] — prices stability achieving, quantified by the relevant medium-term indicator by demand inflation controlling.

Some scientific papers assess specific aspects of monetary instruments use for counter cyclical regulation, including under crisis and instability: O. Dziubliuk [8], M. Savluk [9], N. Hryhoryshyn [10]. Almost every work notes the different effectiveness of the same tools indifferent periods and under different conditions of economic development and financial system.

P. Arestis and M. Sawyer [7] emphasize that the role of central banks in the use of monetary policy instruments has increased significantly in recent decades.I. Kreidych, et. al. [11] investigate the peculiarities of the monetary policy implementation in developed and developing countries, and determine the functionality of both traditional and non-traditional transmission channels to influence the economy, taking into account the dominant factors and conditions. F. Tobias [12] notes that in emergencies, such as the COVID-19 pandemic, the sharp deterioration in economic and financial conditions and growing uncertainty require central banks to take synchronous anti-crisis action to more widely apply monetary policy tools. At the same time, the central bank's measures must be timely, reasonable, transparent and accompanied by appropriate verbal interventions, which is especially important in countries with transformational economies, where it is necessary to achieve a higher level of central bank independence to accelerate decision-making [13—15]. A. Gritsenko, et. al. [15] justified the importance of adhering to the interrelated monetary policy goals, the need to expand the institutional and instrumental capacity of central banks by working with the government to prevent risks of destabilization.

B. Annicchiarico and L. Rossi [16], summarizing the different approaches, emphasize that the inflation targeting strategy of the central banks ignificantly reduces general uncertainty contributing to economic growth. C. Sims and M. Negro [17] note the different ultimate effectiveness of the monetary instruments usage to regulate economic development and the close connection between the monetary base, the rate of federal funds and inflation. I. Chugunov, et. al. [18] stipulates that the long-run, monetary policy should ensure a comprehensive combination of inflation targeting conditions, the adaptive using of tools to achieve intermediate and final targets, while taking into account that the nature of instruments impact is heterogeneous and depends on socio-economic conditions regime of the central bank.

The differences resulting from the application of different monetary policy instruments to different objects in different periods have been reflected in the evolution of the respective models [19]. Thus, in the work of L. Klein [20], who received the Nobel Prize in Economics in 1980, there is a difference between endogenous and exogenous variables, goals and instruments of monetary policy. Given the high predictability of L Klein's model, itoccasionally needed to be corrected for lagging in time. Such adjustments involve variable exogenous instruments, such as defense spending, unsecured government spending, personal federal taxes, guide lines for capital depreciation, and growth targets for M1 and M2 [20].

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The current generation of models of impact of monetary policy on economic development is based on a combination of economic agents optimizing behavior and nominal price and wagerigidity [19]. Thus, DSGE models are used by the central banks of several countries (US Federal Reserve), the Bank of England, the Reserve Bank of New Zealand, the Bank of Russia, Canada, etc.). These models are based on the use of Bayesian methods of combining calibration elements with the assessment of economic development structural parameters.

The main difference of modern models is taking into account the behavior of economic agents. The models resulting parameters are the properties of the economic agents' goals or the constraints they face. The structural content of such models changes as the policy of the country's central bank changes.

The main in consistencies in the monetary policy instruments use justification are: differences in the characteristics of its instruments (their quantitative parameters or features of systematic behavior); in the differences between the understanding of the compromise of target parameters (in Klein's model — the compromise between GDP growth and inflation, in modern models it is the trade-offs between variances of target parameters); differences in the inclusion or exclusion from the list of instruments of fiscal and budgetary instruments (in modern models they are considered exogenous); variability of model parameters when using different modeling methods.

Therefore, the definition of economic development targets in relation to the parameters of monetary instruments (even taking into account their stochasticity or behavioral aspects of the relationship) has a number of important comments. Over coming such remarks is possible under the condition of expanding the system approach in understanding monetary processes, in particular in the crisis period, and taking into account the irpeculiarities when adjusting monetary policy, which determines the study relevance. The article is to determine the characteristics of monetary processes during the crisis areas of economic development and monetary policy adjustments.

Metodology and research metods. The basis of the research methodology is the indeterminacy paradigm of scientific thinking, according to which the instruments of monetary policy are consideredas a part of a heteroarchically organized open system. This system development patterns are defined as contingent, and its transformations depend on the amount of chaos in it. To solve some research problems, the following methods were used: analysis to assess the main monetary indicators dynamics; interpolations to determine their dynamics cyclicity; probabilistic analysis to estimate the parameters of the probability density lines of monetary indicators; entropy estimates to measure the amount of chaos in the information about the quantitative parameters of monetary indicators. Methodical bases of uncertainty level research are described in O. Grabchuk work [21].

The results of the research. The following monetary indicators were used for the study: monetary base (*MB*); cash (*c*); transferable deposits (*TD*); monetary aggregate M0, M1, M2, M3 (MA_{m0}, MA_{m1}, MA_{m2}, MA_{m3}); participation in the capital (*PC*); net external assets (*NEA*); credit internal (*CI*).

All statistical data are taken from the National Bank of Ukraine official website [22] for the period 2005—2020 on a monthly basis.

The initial stage of the study was to identify the existence of a certain temporal pattern of the outlined indicators dynamics with the greatest possible accuracy (*Table 1*).

With high reliability the existence of the annual cycling of almost all described monetary characteristics was confirmed. In the following equations, the variable t corresponds to the linear numbering of time intervals, the variable $t^{/}$ — corresponds to the periodic numbering. The approximation error determined by the variance analysis results does not exceed 1.5%. The use of other forms of approximation did not make it possible to describe the dynamics lines with a reliability more than 90%.

Table 1

Theoretical approach of monetary dynamics characteristics descriptionlines

Indicator	Theoretical approximation description line	Cyclicality		Approximation error
		existence	cyclelength, months	
Monetary base, *MB*	$MB(t,t') = 49340 + 2143 \cdot t - 9552 \cdot \cos(t') + 6499 \cdot \sin(t')$	+	12	0,01467
Cash, *C*	$C(t,t') = 43667 + 1085 \cdot t - 10760 \cdot \cos(t') + 1330 \cdot \sin(t')$	+	12	0,01119
Transferable deposits, *TD*	$TD(t,t') = 9181 + 221 \cdot t - 1008 \cdot \cos(t') + 191 \cdot \sin(t')$	+	12	0,0102
Monetary aggregate M0, MA_{m0}	$MA_{m0}(t,t') = 39952 + 1835 \cdot t - 10022 \cdot \cos(t') + 1204 \cdot \sin(t')$	+	12	0,01199
Monetary aggregate M1, MA_{m1}	$MA_{m1}(t,t') = 40154 + 3347 \cdot t - 18250 \cdot \cos(t') + 3080 \cdot \sin(t')$	+	12	0,01249
Monetary aggregate M2, MA_{m2}	$MA_{m2}(t,t') = 113254 + 6785 \cdot t - 28375 \cdot \cos(t') + 10345 \cdot \sin(t')$	+	12	0,01122
Monetary aggregate M3, MA_{m3}	$MA_{m3}(t,t') = 115608 + 6782 \cdot t - 28472 \cdot \cos(t') + 10479 \cdot \sin(t')$	+	12	0,01129
Participation in the capital, *PC*	$PC(t) = -232850 + 114425 \cdot Ln(t)$	–	–	0,00179
Net external assets, *NEA*	$NEA(t,t') = -9756 + 1057 \cdot t + = 4188 \cdot \cos(t') - 11457 \cdot \sin(t')$	+	54	0,00808
Credit internal, *CI*	$CI(t,t') = 84237 + 10465 \cdot t - 19557 \cdot \cos(t') + 28176 \cdot \sin(t')$	+	12	0,01441

Source: Compiled by the authors based on data [22].

Monetary aggregate M0 dynamics patterns allow us to state that its initial volume, determined analytically, amounted to UAH 39,952 million, and UAH 3,715 million cash was in depository corporations. Swing of monetary aggregate M0 during one cycle were up to 33% of its value at the beginning of the cycle, whiles wings of all cash — 27.7%. With a general upward trend in both the M0 aggregate and cash in general, from each hryvnia emited with in depository corporations remained UAH 0.408.

Monetary aggregates M1, M2 and M3 dynamics were similar. The initial volume of transferable deposits in the national currency amounted to UAH 202 million, transferable deposits in foreign currency and other deposits — UAH 73,100 million, the volume of securities (excluding shares) — UAH 2,354 million. Monetary aggregate M1 cyclical swing range was determined at the level of 53% of its value at the beginning of the period, for the aggregate M2 cyclical swing range was 34.4%, for the aggregate M3 — 33.7%.

In general, money supply components dynamics patterns are subject to a fairly accurate mathematical description and are predictable in the long run. The forecast horizonis at least twelve months. At the same time, there is no danger of imbalance of monetary aggregates, because cyclic phases in them coin cide, as well as the cycle duration.

However, any economic characteristic is significantly affected by random fluctuations, so-called «white noise». Based on the assumption that the laws of money supply, monetary base and other monetary characteristics are determined by the economic processes laws, thehypothesisisformulated: monetary characteristics dynamics uncertainty is determined by the uncertainty of random deviations from the lines of theoretical approximation of their empirical values. Entropy (*Table 2*) and entropy production were used to measure uncertainty.

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Table 2

General description of monetary indicators uncertainty level

Indicators	Entropy of dynamics		Average annual entropy		Average annual entropy production	
	By empirical data	By deviations from the lines of theoretical approximation of dynamics	By empirical data	By deviations from the lines of theoretical approximation of dynamics	By empirical data	By deviations from the lines of theoretical approximation of dynamics
Monetary base, *MB*	3,5121	3,4365	3,2103	3,6160	-0,0603	-0,0599
Cash, *C*	3,5930	3,5319	3,6882	3,7553	-0,0977	-0,0235
Transferable deposits, *TD*	3,6151	3,1917	3,6369	3,9804	-0,0343	-0,0186
Monetary aggregate M0, MA_{m0}	3,5626	3,4460	3,7319	3,5917	-0,0672	0,0039
Monetary aggregate M1, MA_{m1}	3,5857	3,3157	3,6854	4,1750	-0,1548	-0,0548
Monetary aggregate M2, MA_{m2}	3,7037	2,9563	3,2606	4,6063	-0,0891	0,0007
Monetary aggregate M3, MA_{m3}	3,7014	2,9521	3,4718	4,6348	-0,0753	-0,0131
Participation in the capital, *PC*	3,3312	3,5059	4,0424	3,8486	-0,0257	-0,0693
Net external assets, *NEA*	3,0533	2,9773	4,7324	4,6722	-0,1709	-0,0277
Credit internal, *CI*	3,4768	2,6012	3,8151	5,2844	-0,1074	-0,0369

Source: compiled by the authors.

Note that the definition of entropy makes sense only on the assumption that the process is completely random. In this study, we believe that the monetary indicators formation process is both natural and random.

According to the results, the predominant share of monetary indicators entropy is formed by random deviations from the lines of theoretical approximation of dynamics. Moreover, the distribution of empirical values is binomial, and the distribution of deviations from the lines of theoretical approximation is normal. Monthly entropydynamics according to all monetary indicators empirical datashows three periods of significant dissipation: July 2007 — July 2008, March 2013 — January 2014, January 2020 — June 2020. These periods preceded the actual manifestation of the crisis in monetary sphere. At the same time, during the whole period under review (2005—2020), entropy production was negative, which confirms the dominance of dissipative processes and indicates self-organization in the monetary system without signs of economic growth. Selected periods do not coincide in any way with the peculiarities of macroeconomic dynamics or with the monetary regime [10]. Thus, the period up to 2014 is defined by Hryhoryshyn as crisis with the eclectic monetary regime, the term 2015—2016 as financial stabilization period with the monetary targeting regime, the term 2017—2019 as economic growth period with the inflation targeting regime. At the same time, negative production of entropy indicates an exacerbation of the crisis in economy as a whole and in monetary sphere throughout this period.

Despite the fact that mainly entropy of empirical values of monetary indicators is formed by the entropy of deviations from the lines of theoretical approximation, the level of uncertainty of their dynamics differs significantly from zero (*Fig. 1*).

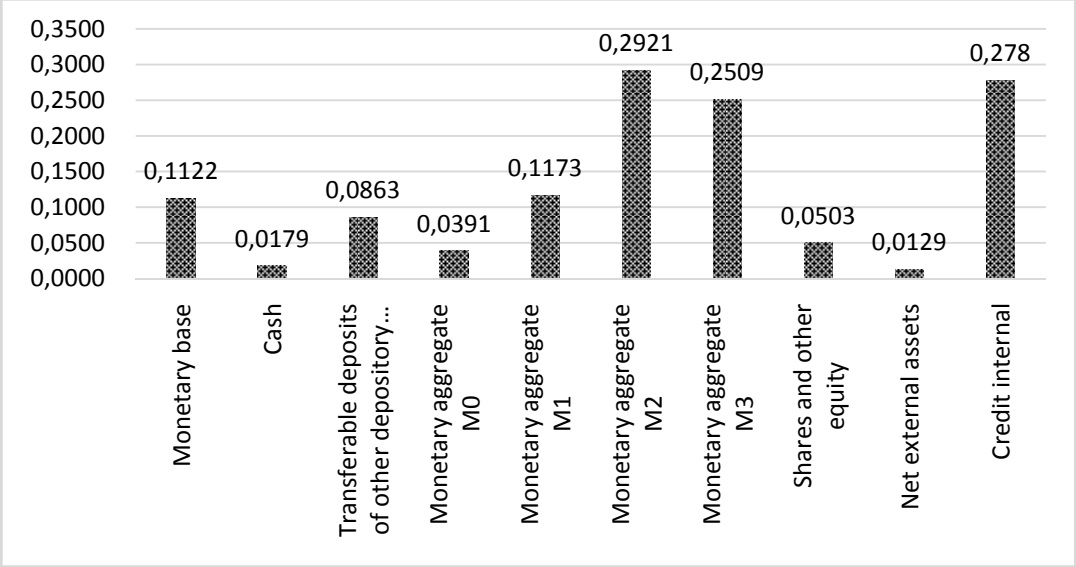

Fig. 1. **The level of monetary indicators dynamics uncertainty**

Sources: compiled by the authors based of calculations.

The last indicator is determined by the formula:

$$H_D = \left| \frac{\sum_{i=1}^{n} P_i \cdot \log_a P_i}{\sum_{i=1}^{n} P_i^{/} \cdot \log_a P_i^{/}} - 1 \right|,$$

where H_D — dynamics uncertainty; P_i — the probability of financial process characteristics empirical values; $P_i^{/}$ — the probability of deviations from the line of financial process characteristic sempirical data theoretical dynamics.

Based on the fact that the approximation error in all cases was insignificant, monetary indicators show a certain level of uncertainty, according to this characteristic they can be divided into three groups:

- indicators with a minimum level of uncertainty in the dynamics: cash, monetary aggregate M0, net external assets, shares and other equity;
- indicators with an average level of uncertainty of dynamics: monetary base, transferable deposits of other depository corporations, monetary aggregate M1;
- indicatorswith a significant level of uncertainty in the dynamics: monetary aggregate M2, monetary aggregate M3, credit internal.

Given that monetary aggregates financing base has an average level of uncertainty, the sources of uncertainty of monetary processes are hidden in foreign currency and other transferable deposits, which distinguish aggregate M2 from aggregate M1. The monetary processes uncertainty inducing is illustrated by the systems of relationships between entropies (*Fig. 2*) and entropy productions (*Fig. 3*) of monetary indicators.

These systems of relationships between monetary indicators empirical data entropies demonstrate the existence of monetary aggregates formation mechanisms, different from their classical understanding.

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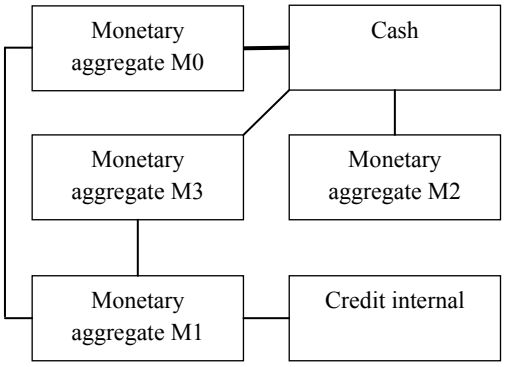
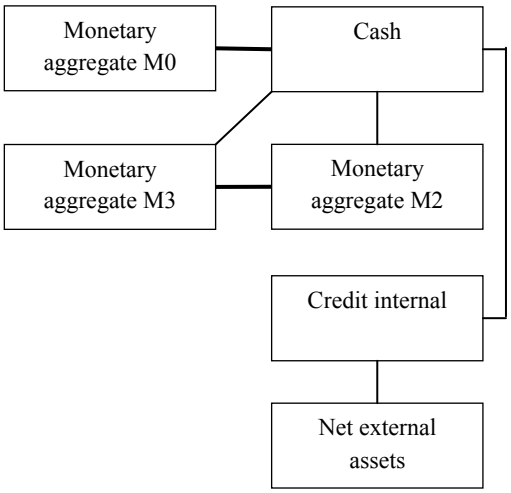
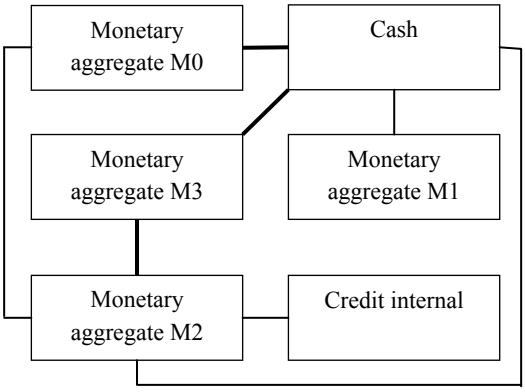


The system of relationships between monetary indicators empirical data entropies

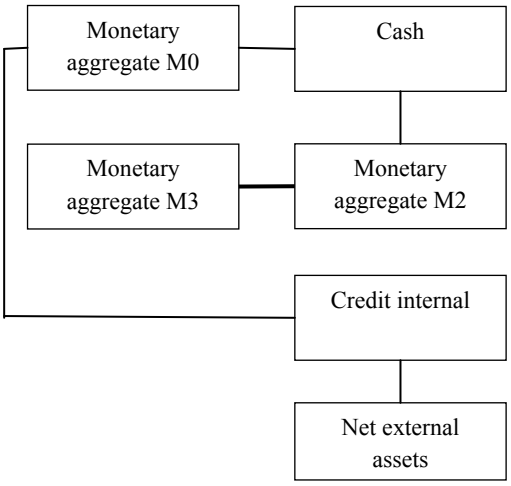


System of relationships between entropies of deviations from the lines of monetary indicators dynamics theoretical approximation

Fig. 2. **The system of relationships between monetary indicators entropies**
Source: compiled by the authors.



The system of relationships between production of entropies of monetary indicators empirical data



The system of relationships between production of entropies of deviations from the lines of monetary indicators dynamics theoretical approximation

Fig. 3. **The system of relationships between the production of entropies of monetary indicators**
Source: compiled by the authors.

The linear relationship $M0 \to M1 \to M2 \to M3$ becomes branched —$M0 \overset{\leftrightarrow cash \leftrightarrow M1}{\leftrightarrow M3 \leftrightarrow M2}$, and there is no other relationship between M1 aggregate entropy and the other monetary aggregates entropies. Thus, transferable deposits in the national currency carry a significant level of uncertainty, ultimately causing monetary aggregates complex uncertainty. However, M1 empirical values uncertainty is generated by its dynamics laws, as evidenced by the system of relationships between the entropy and deviations from the lines of theoretical approximation. The relationship between the monetary aggregates dynamics uncertainties takes the form $M0 \leftrightarrow cash \overset{\leftrightarrow M2}{\leftrightarrow M3}$ that indicates the mutual induction of «white noise» in the aggregates M0, M2, M3.

Following practical conclusions on ensurance the main monetary indicators entropy reduction derive the obtained results:

- it is necessary to restrain the growth of transferable deposits in the national currency, which will reduce the entropy level of M1 aggregate;
- it is necessary to intensify the regulation of cash in circulation, which will reduce random fluctuations of M0, M2, M3 aggregates.

These instruments are mostly in line with the restrictive monetary policy [23] with one important cave at — it is necessary to create a liquidity crisis in combination with an increase in interest income from lending.

It should be borne in mind that an increase in entropy is not only an evidence of an increase in the level of monetary system uncertainty, but also accompanies economic growth in general. Thus, ensuring economic growth must correspond to the opposite directions of monetary regulation:

- providing transferable deposits in national currency proactive growth;
- cash circulation increase.

Moreover, given the fact that stimulating growth is appropriate with the existing maximum system dissipation, the priority is to saturate the economy with cash, which will increase the «white noise» in the monetary sphere. Then, it is deferred necessary to stimulate the growth of transferable deposits in the national currency. In other words, the difference between the interest at which funds are provided to the economy and the interest at which they are attracted from the economy should be reduced («expensive deposits — cheap loans»).

Similar conclusions canals obedrawn from the system of relationships between the production of monetary entropies (see *Fig. 3*). It is known that the production of entropy indicates the dissipation or development of a complex system [24, p. 76—78]. The production of entropy according to monetary indicators empirical data has the following connections system:

$$\begin{array}{rl} & \leftrightarrow M1 \\ cash & \leftrightarrow M0 \downarrow \\ & \leftrightarrow M3 \leftrightarrow M2 \end{array}$$

Comparing with the system of relations between the monetary indicators empirical values entropies, we see a set of differences and common features:

- the source of growth / decrease in the uncertainty of monetary processes is the uncertainty of cash amount. Thus, monetary processes dissipation or growth is determined by the amount of «white noise» in cash fluctuations, which confirms both the priority and precedence of regulating fluctuations in cash to ensure monetary system dynamics route;
- between M0, M2, M3 aggregates random fluctuations there is not just an interdependence, but a mutual cyclic dependence. In other words, the induction of «white noise» is mutual and inverse.Cash mass primary fluctuations, causing uncertainty simultaneously in M0, M2 and M3 aggregates, will determine their instability and exponential increase in entropy level;
- at the same time, there is the same connection between the production of entropy in cash mass and M1 monetary aggregate as between their entropies. This indicates the possibility of M1 aggregate (as a tool for partial accumulation of entropy of cash) using. It confirms the previous conclusion about the sequence of these tools implementation to regulate monetary processes.

To ensure economic growth, it is necessary to increase the amount of cash in economy, and then after a certain period of time — to reduce the spread between the cost of borrowed resources and the fee for their use. The specified time interval must correspond to the smallest lag of action in cash — M0 and cash — M3 relations. The duration of cash — M0 entropy relations lag, determined analytically, is 5.4 months, cash — M3 entropy relations is 7.8 months. Thus, the transition to the provision of public monetary policy «expensive deposits — cheap loans» (expansionary monetary policy) should take place no later than 5 months after the infusion of additional cash into the economy. It should protect against the exponential entropy production in the monetary system. On the one hand, even excessive entropy production in a system that is in extreme dissipation will

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initially contribute to significant economic growth, on the other hand, exponential entropy growth will determine the short period of such growth.

Top revent the system collapse, its excessive dissipation, it is necessary to use the reverse order of monetary instruments application. First, there is an increase in the spread between the cost of borrowed resources and the fee for their use («cheap deposits — expensive loans»), and then — the laundering of cash from the economy over a period of time corresponding to the smallest lagin the relationship $cash \leftrightarrow M0$ and $cash \leftrightarrow M3$. Moreover, the determining element in ensuring the stabilization of entropy production in the complex M0, M2, M3, as evidenced by the system of relationships between entropy production deviations from the lines of theoretical approximation of the dynamics of monetary indicators, is to reduce «white noise» of M3. As a rule, the source of fluctuations of M3 are market processes in the derivative financial instruments market. Thus, ensuring a moderate dissipation of monetary processes can be achieved by suspending the circulation of derivative financial instruments. However, thereare a number of tools that can enhance the restrictive effect, including fiscal. In particular, stimulating cash laundering from the economy can be achieved through increased turn over taxation, savings in public spending and reduction of public investment [14]. Such instruments were used by the National Bank of Ukraine during 2014—2020, when the system dissipation level was quite significant. In 2015—2016, the implementation of restrictive monetary policy was embodied in the application of a high discount rate (28.04%, 17.95%), overnight credit and deposit mechanisms. This made it possible to reduce the monetary instruments fluctuation and to stabilize the financial system. Stabilization was also facilitated by the cleansing of the banking system [10]. Since 2016, the monetary policy content focus has shifted from monetary targeting to inflation targeting. The main activity of the National Bank was to achieve a stable level of inflation, which should not exceed a certain level. During this period, Ukraine's economy was still on a down ward trend and a strictrestrictive policy, despite the need to apply it to stabilize the monetary component, determined the further dissipation of the economy as a whole, which led to reduced effective demand and the collapse of the real sector. Negative impact of systemic risks and threats (military action in eastern Ukraine, the destructive impact of the COVID-19 pandemic and numerous restrictions and quarantines) determined the achievement of a critical level of entropy by various monetary indicators. Thus, the average monthly entropy for the monetary base at the end of 2020 reached 0.209, for cash — 0.26, for the monetary aggregate M0 — 0.28, M1 — 0.24, M2 — 0.22, M3 — 0.24. Such indicators of the level of entropy by elements of a homogeneous system indicate the fading of its development. Of course, it is necessary to study the elasticity of the system interms of its adaptation to fluctuations of individual monetary components, but further dissipation can lead to its destruction in the event of a negative «blackswan».

In contrast to Ukraine's current restrictive monetary policy, during the crisis (2008), the US Federal Reserve and the European Central Bank (ECB) pursued an expansionary monetary policy [17, p. 2426], which, however, had very different quantitative characteristics. Thus, the FRl owered interest rates very sharply and very significantly, while the ECB — slowly and in significantly, using mostly institutional measures. As a result, the ECB's monetary policy has yielded more effective results, turning the staggering economic down turn into a slow down in development and further alignment.

The events of 2020 also show the transformation of Ukraine's restrictive monetary policy into expansionary — government spending has increased significantly (including investment — for significant infrastructure projects), the NBU discount rate has decreased significantly (up to 8%), the minimum wage has risen and more. However, significant money laundering from the economy in previous periods and declining incomes due to quarantine restrictions have not yet led to increased financing of effective demand.

Conclusion from the conducted research. The assessment of the main monetary indicators dynamics regularities (monetary base, volume of cash, volume of transferable deposits of other deposit-taking corporations, volume of monetary aggregates M0, M1, M2, M3, volume of shares and other forms of participation in capital, volume of net external assets, volume of internal credit)

according to the National Bank of Ukraine data in the monthly context for the period 2005—2020 made it possible to state their affinity and cyclicity with a cycle length of about 1 year. At the same time, an increase in the range of cyclical fluctuations of monetary indicators and the level of «white noise» of their random deviations from the line of cyclical dynamics was noted.

The hypothesis that monetary indicators dynamics uncertainty is determined by the uncertainty of«white noise» of their random deviations from the lines of cyclic dynamics based on the entropies of the dynamics and the dynamics of entropies calculation is put forward and confirmed. Three corpses of monetary indicators have been formed according to the level of uncertainty in them: with minimum level of dynamics uncertainty (cash, M0 monetary aggregate, net foreign assets, shares and other equity); with average level of dynamics uncertainty (monetary base, transfer deposits of other depository corporations, M1 monetary aggregate); with significant level of dynamics uncertainty (M2 monetary aggregate, M3 monetary aggregate, credit internal).

Based on the assessment of entropy production, the dissipation of all monetary indicators in the period under consideration was confirmed, with its significant acceleration in the subperiods preceding the manifestation of crisis phenomena in the monetary sphere (07. 2007 — 07. 2008, 03.2013 — 01.2014, 01.2020 — 06.2020). Analysis of the relationship between entropy and entropy production allowed us to identify sources of uncertainty in the monetary sphere: the amount of cash in connection «cash — M0» with a lag of 5.4 months and the amount of cash in connection «cash — M3» with a lag of 7.8 months. Uncertainty of processesin M1 and M2 monetary aggregates is caused by their connections with M0, M3 aggregates.

Entropy generation features in relations system of monetary indicators allowed suggesting directions to overcome the crisis in Ukraine monetary sphere, due to the need to stabilize production entropies. Given the significant level of dissipation of monetary indicators in Ukraine, it is appropriate to change the restrictive monetary policy to the expansionary one, taking into account the lag in the relationship between entropies / entropies production of the main monetary indicators.

The obtained results can be of practical importance in the system of state regulation to stimulate monetary circulation not only in crisis but also in post-crisis periods, ensuring key monetary indicators long-term stability and monetary policy effectiveness improving.

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