The object of the study is monetary processes and the real sector of the economy. The purpose of the study is to analyze the impact of monetary processes in the economy on GDP based on a systematic approach. The task of analyzing the relationship between the main indicators of monetary processes and GDP on the basis of a wide sample of countries was solved. The results are obtained:

– for the variables included in the cluster analysis, the money supply analyzed: (1st cluster "stable financial environment" – 0, 2nd cluster "high access to credit" – 147.7, 3rd cluster "limited access to credit" – 72.2, 4th cluster "high interest rates" – 30.4 % of GDP);

– 72 countries are divided into 4 clusters, with 13 countries in the first cluster, 15 in the second, 21 in the third, and 23 in the fourth. This allows to determine the nature and place of the economy in the world and to make monetary policy decisions;

– there is a positive correlation between GDP and money supply (r=0.317); there is a weak positive relationship between GDP and the credit information depth index (r=0.203); there is a moderate positive relationship between GDP and domestic lending (r=0.39). Money supply management and domestic credit should be prioritized in monetary management of the economy.

The obtained results are explained by the assumption of linear dependence between the indicators of monetary processes and the real sector of the economy. This assumption was confirmed on the example of different countries, which indicates its universality.

The peculiarities of the results obtained are the application of a combination of cluster and correlation and regression methods of analysis using actual World Bank data

Keywords: monetary processes, GDP, depth of credit information, money supply, domestic credit

UDC 336
DOI: 10.15587/1729-4061.2024.306446

SYSTEMATIC APPROACH TO ANALYZING THE IMPACT OF MONETARY PROCESSES IN THE ECONOMY ON GDP

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Received date 02.04.2024
Accepted date 17.06.2024
Published date 28.06.2024

How to Cite: *Gumar, N., Zhanibekova, G., Imramziyeva, M., Zholdasbayeva, T., Bessekey, Y., Kenzhin, Z. (2024). Systematic approach to analyzing the impact of monetary processes in the economy on GDP. Eastern-European Journal of Enterprise Technologies, 3 (13 (129)), 79–90. https://doi.org/10.15587/1729-4061.2024.306446*

1. Introduction

The increased uncertainty in the development of economic processes due to both the segmentation of the global market against the background of economic and political obstacles and sharp technological changes in production systems call into question the established growth strategies of national economies. In this regard, the significance of the system approach to the study of monetary processes is actualized, which allows to better understand the peculiarities of the crisis development of the financial system and its impact on the real sector of the economy. The system approach provides an opportunity to apply a unified approach to the analysis of all elements of monetary relations, to determine the boundaries of the action of each element and its manifestations in reality, to outline the links between them, to identify and make necessary adjustments to change their influence in a particular period.

The impact of monetary processes on the real economy is of particular importance for newly independent states developing market conditions of economic management. Without knowledge of the consequences of changes in the monetary sphere, the establishment of economic policy objectives and the definition of measures for their implementation, as well as the assessment of prospects for economic development, may be erroneous. Monetary processes act as an important lever of the market economy, and their sustainability determines its normal functioning.

On the other hand, the real sector of the economy has a significant impact on the functioning of the monetary sys-

tem, being the material basis and source of its development. The rate and nature of changes in inflation, receivables and payables, the level of profitability and unprofitability of economic sectors and other important factors determine the economic environment of the country's market. Underdevelopment of monetary processes hinders the spread of monetary impulses in the economy. Normalization of the macroeconomic situation and sustainable economic growth are based on the stabilization of monetary circulation, money market equilibrium, attractiveness of investment credits for the real sector of the economy. Failure to take into account the peculiarities of the national economy in determining monetary regulators may lead to undesirable effects.

Thus, the relationship between the functioning of the monetary and real sectors of the economy requires concretization. Therefore, the study of issues related to the nature of their interaction is currently acquiring high relevance and scientific significance. There is a need to develop new theoretical and methodological provisions substantiating the impact of monetary processes in the economy on GDP in the conditions of the economies of different countries, which will make it possible to identify the channels and degree of influence of monetary processes on the real sector of the economy.

2. Literature review and problem statement

The diversity of theories of monetary relations in the economy is largely due to the originality of the formation of paradigms arising in the process of interpretation of the Keynesian model of interaction between monetary and fiscal mechanisms of economic functioning. It is the different understanding of the essence of money that generates conceptual disagreements in such interpretations.

Thus, according to the representative of post-Keynesianism [1], money is a special social institution that influences other institutions. The review of this study shows the basic idea that monetary policy mechanisms, different from the traditional ones, are based on the concept of the influence of money, which can be used as a basis for analysis in the short and long term.

The impact of globalization processes significantly complicated the task of ensuring the independence of national economies and contributed to the spread of the idea of the state theory of money, represented in the concept of sovereign money [2]. The analysis of this concept allows to emphasize the focus on the importance of the creation by the state of institutional regulators of the monetary system, corresponding to the realities of the economy. But at the same time the interrelations with the theory of the market are not sufficiently shown.

In the opposite direction, since the end of the XX century, the modern monetary theory, which integrates post-Keynesianism and new institutionalism, has been developing [3]. A review of this theory shows that it develops theoretical descriptions that exclude the shortcomings of traditional theories caused by a wrong understanding of the role of the state in the economy, excessive giving importance to the "invisible hand" of the market and monetary mechanisms. This direction seems to be reasonable and systematic.

The study [4] argues that monetary instruments play an important but auxiliary role aimed at implementing structural changes in the economy. A critical analysis of this study leads to the conclusion that this approach is developed within the framework of methodological individualism, as the importance of competitive forms of behavior of economic actors of the market is absolutized.

According to [5] the main principle applied in monetary regulation should be a synthesis of Keynesian and neoclassical theory based on the use of dynamic stochastic general equilibrium model. But criticism of this principle shows that in reality there are theoretical and methodological problems associated with formal contradictions in the model when applying unrealistic scenarios and using a significant number of unobserved data (compared to observed data).

The study [6] shows that when real GDP grows and money supply increases, the interest rates on the regulator's operations begin to gradually decrease, which reduces the fluctuations of rates in the money market and ensures the stability of the economy. The analysis of this study in its graphical part shows that lowering the interest rate and increasing the GDP indicator entails an upward shift of the money demand curve. Consequently, in order to ensure equilibrium between the demand and supply of money, it is necessary to increase the supply of money from the regulator, because the increased level of demand for money will correspond to the previous level of prices. In order to maintain equilibrium between the demand and supply of money, it is necessary for the regulator's supply of money to increase, which will cause the increased level of demand for money to match the previous price level.

Another study [7] found that the downward tendency of the price level to absolute rigidity makes it unlikely that there will be a slowdown in the rate of price growth, which is usually restrained by an increase in the money supply. Unless there is an increase in money supply of this size, there will be disequilibrium in the money market resulting in downward pressure on output and upward pressure on the rate of interest. It is concluded that a decrease in output and an increase in the rate of interest entail a decrease in the demand for real money balances, causing a disturbance in the equilibrium between supply and demand in the money market. But this conclusion is not statistically verified.

In the article [8] the study of short-term intervals showed that the effects of changes in the demand and supply of money, as well as changes in the money supply and its reduction, are of different nature. Because of this, functional relationships and models can only describe the direct effects and not the inverse effects. For example, in some cases, an increase in the money supply can lead to an increase in prices. Critically evaluating this result, let's note that it is not necessarily the case that a reduction in the money supply under the same conditions will cause a proportional decrease in prices. A reduction in the money supply may generate qualitatively different effects: a decline in production, an increase in average costs and, as a consequence, an increase rather than a decrease in prices.

The monograph [9] notes that in order to achieve the target values of inflation, the regulator needs to take into account many factors that are not always controllable. The use of monetary instruments can cause destabilization of economic processes. But the monograph does not provide factor analysis for confirmation.

The study [10] argues that the use of alternative indices instead of the consumer price index as a target for the impact on GDP creates confusion among economic participants. These indices, "purified" from the impact of external fac-

tors such as world price fluctuations, administrative price controls and seasonal fluctuations, may undermine public confidence in monetary policy. However, there is no experimental evidence in this study to assess public confidence or changes in the behavior of economic participants in the above situation.

The article [11] substantiates the opinion that the conflict of objectives and increase in macroeconomic imbalances will be inevitable if the regulator focuses on several directions (inflation reduction, stable exchange rate, increase in household incomes) for GDP growth. But no historical or country-specific examples of such imbalances are given.

The study [12] argues that changes in the rate of price growth are not subject to the direct impact of the regulator, because there is a significant time interval between its actions and economic consequences. Monetary policy will start to have an effect on GDP only when it has already moved away from the equilibrium state. A critical analysis of the methods applied in this study showed that the forecasting method, which allows smoothing time lags in monetary processes, was left out. Consequently, this statement cannot be absolute in nature.

In the paper [13] it was found that the behavior of economic agents in the money market and their preferences regarding the structure and currency of assets depend on the dynamics of inflation and manifest themselves in a delayed manner. This is due to the analysis of the relationship between money supply aggregates and inflationary processes. When deposits in foreign currency increase, the demand for real money balances in national currency decreases due to the growth of inflation rates. The plus side of this study is that the relationship between foreign currency deposits and consumer price index is established by analyzing its closeness, as well as by the currency component of broad money supply. Nevertheless, the results are applicable only to the conditions of the economy with high dollarization.

More extended results were obtained in the study [14]. The analysis showed that the relationship between investment, inflation and time deposits does not have a direct impact on GDP growth, and the reduction of inflationary processes, increase in the volume of time deposits and positive dynamics of the money supply structure are not the main factors for the reduction of interest rates. But this analysis was conducted using only one methodology and on the basis of data from one country.

When studying the data [15] it was found that there is a direct dependence of the liquid part of the money supply on receivables and payables. It is shown that the growth of deposits entails an increase in non-payments in the economy. Real sector enterprises face difficulties in meeting their obligations and instead increase their income at the expense of assets. In order to solve the problem of non-payments and monetization of economic turnover, it is proposed to create conditions for the transfer of cash flows from financial markets to real production in order to ensure GDP growth. However, this proposal in the study [15] was not tested by econometric modeling, which leaves it hypothetical.

A significant positive correlation was found when analyzing the relationship between interest rates, inflation and the volume of deposits in the banking system in [16]. Decrease in interest rates in the national economy and slowdown in inflation lead to a decline in the growth rate of deposits in the short term. The disadvantage of this study is the lack of analysis of deposit growth rates in the long-term trend.

In the course of analyzing the impact of money supply on aggregate demand and GDP of the economy, the paper [17] identified three main directions of monetary transmission in the form of inflation expectations channel, substitution channel and monetarist channel. The substitution channel is based on the choice between saving and spending depending on the change in the market interest rate. Consumption decreases and interest in saving increases when the interest rate rises. Decreasing interest rates make saving less attractive as the growth rate of deposits falls. However, this study does not analyze the interest rate channel in its impact on the overall economic situation, which is relevant to investors' expectations. Thus, the article [18] emphasizes that in the transit economy, the absence of the bank lending channel is explained by the objective limits of lending and the low creditworthiness of enterprises. This implies the short-term nature of attracted resources of banks and the widespread use of targeted financing of individual industries in order to increase their share in GDP (quasi-credit channel).

As the study [19] shows, the functioning of the inflation expectations channel in the economy of many countries is associated with the application of the strategy of fixed exchange rate of the national currency to the USD. This approach allows to significantly reduce the level of inflation expectations. Agreeing with this position, in this study it is possible to use financial indicators of the economies of different countries in USD.

The review process also found a study comparing monetization levels in different countries [20], which evaluated the relationship between monetary aggregates, investment and GDP. The study concluded that regardless of economic development GDP benefits from an increase in money supply. However, the level of monetization of GDP cannot be the only criterion for determining the economy's need for money. A critical analysis of the article shows that the lack of universally accepted standards for the monetization ratio makes its values strictly individual for each country and time period. This is similar to the individual values of the demand for money and the degree of confidence in the national monetary system. Therefore, when determining the monetization ratio, it is necessary to take into account the level of development of the financial environment and domestic credit.

Thus, there are no reveal objective and sufficient results of analyzing the impact of monetary processes in the economy on GDP. It is revealed that the impact of monetary processes in the economy on GDP uses multivariate statistical procedures. This requires analysis by a group of valid methods to obtain reliable conclusions about the presence/absence of the relationship between GDP as a resultant indicator of the real sector of the economy and key indicators of its monetary processes.

3. The aim and objectives of the study

The aim of the study is to identify the impact of monetary processes in the economy on GDP based on a systematic approach. This will make it possible to determine priorities in the monetary regulation of the economy.

To achieve this aim, the following objectives are accomplished:

– to determine a method of clustering countries to analyze the impact of monetary processes on GDP;

– to the analysis of the financial stability of countries based on clusterization;

– to conduct a correlation and regression analysis of the relationship between the indicators of monetary processes and GDP.

4. Materials and methods

The object of the study is monetary processes and the real sector of the economy. The hypothesis of the study: there is a positive correlation between GDP and:

1) money supply;

2) the index of the depth of credit information;

3) internal lending to the financial sector.

The research assumes that inflationary processes for the sample countries are constrained by the dollarization of the money supply. There is also a simplification in the work that banks operate in conditions of pure competition. This made it possible to neutralize the political and economic differences of a large sample of countries.

The research uses modern analytical research methods, including in-depth analysis, cluster analysis, as well as economic-statistical and correlation and regression analysis.

A cluster analysis is proposed to determine the best and worst cluster based on the results of fundamental research and the determination of the global innovation index and credit information depth:

– within-cluster variation – one of the indicators used to assess the quality of clustering is within-cluster variation. The smaller the variation within a cluster, the more compact and homogeneous the cluster is. The ideal scenario is when the within-cluster variation is minimized for all clusters;

– inter-cluster distance refers to the distance between the centers of different clusters. The greater the distance between clusters, the more distinct and separated they are;

– external validation is used to assess the quality of clustering by comparing the clustering results with known groups or class labels. If the clusters align well with the original groups or classes, it indicates a good quality clustering;

– cluster visualization helps in determining the best and worst clusters. If the clusters are visually distinct and transparent, it suggests better clustering. On the other hand, if the clusters merge or overlap, it indicates poor clustering;

– domain expertise can provide insights into which clusters are meaningful or relevant for interpretation in a specific field.

For cluster analysis, let's use the aforementioned factors for fundamental research, such as money supply (% of GDP), deposit interest rate (%), and loan interest rate (%), using the k-means method in the specialized SPSS package [21].

The selection of initial cluster centers influences the results of clustering. The k-means method is an improved approach to random selection and is suggested for more efficient and stable initialization of cluster centers in the algorithm. The method randomly chooses the first center and then selects subsequent centers in a way that excludes them from the previously chosen centers, considering their importance.

Correlation-regression analysis is used to examine the relationship between two or more variables. It allows to determine the strength and direction of the relationship between variables and predict one variable based on another or multiple variables.

This allows for a more detailed understanding of the relationships and better comprehension of the factors influencing the variables within the cluster. For the correlation-regression analysis, the following indicators were selected for each country: GDP in billion dollars as the dependent variable, and money supply (% of GDP), deposit interest rate (%), lending interest rate (%), capital and bank assets (%), net purchase of financial assets (% of GDP), credit information index (0=low and 8=high), domestic credit provided by the financial sector (% of GDP) as independent variables [22].

5. Results of cluster analysis of the impact of monetary processes in the economy on the country's GDP

5. 1. Defining a methodology for clustering countries to analyze the impact of monetary processes on GDP

Cluster analysis of the impact of monetary processes on the country's GDP is carried out on the basis of the theory of macroeconomic models. For this purpose, methods of data analysis are used, in this study the hierarchical cluster analysis (k-means method) is applied. The econometric model VAR on Statistica 12.0 software was used for the analysis. The clustering technique is described in detail in the previous section. Source data on countries are taken from the official website of the World Bank [23].

Introductory indicator of clustering for analysis is the Depth of credit information index in the country (0=low and 8=high). If the coefficient is equal to 0, it means that the level of accessibility and quality of credit information in the country is very low. In such countries, access to borrower information may be limited, and credit institutions may find it difficult to assess the creditworthiness of potential borrowers (Table 1).

In Table 2, 72 countries are divided into 4 clusters.

The initial cluster centers in the cluster analysis method are the initial points selected to initialize the clustering process. They serve as initial approximations for the cluster centers and act as starting points for subsequent computations and center updates during the clustering process. Table 3 is presenting analysis of initial cluster centers by factors.

Analysis of variance (ANOVA) in cluster analysis is used to determine the statistical significance of differences between clusters based on selected variables (Table 4). It assesses how much the environments of selected variables differ between clusters, and determines the statistical significance of those differences.

A cluster analysis of money supply, deposit interest rates, and credit interest rates has been conducted, and the final cluster centers represent the mean values of these indicators for each cluster (Table 5). This allows to determine which clusters have high or low values for these indicators.

A graph was constructed based on the results of the analysis of the final centers of the clusters using the factors in Table 5 (Fig. 1).

The final cluster centers represent the mean values of features for objects belonging to each cluster. The final cluster centers can also be used for classifying new objects by assigning a cluster label based on the nearest final cluster center.

Table 1

Grouping of countries by indexing depth of credit information

0=low and 8=high	Countries	GDP billion dollars	Money supply (% GDP)	Bank's capital and assets ratio (%)
1	2	3	4	5
0	Bangladesh	351.20	55.80	4.80
	Iraq	207.90	41.90	14.20
	Algeria	170.10	81.60	9.90
	Nepal	33.40	97.20	10.40
	Bahamas	12.40	56.30	–
	Barbados	5.00	113.80	10.20
	Burundi	2.70	39.60	12.20
	Dominica	0.60	102.00	4.60
2.00	Comoros	1.20	28.00	11.00
5.00	Sweden	547.10	74.10	5.70
	Belgium	535.80	–	6.30
	Bulgaria	68.90	85.10	11.50
	Cyprus	25.60	–	8.70
	Montenegro	5.50	58.00	9.20
6.00	France	2,728.90	0.00	5.40
	Norway	404.90	65.90	0.00
	Denmark	355.20	62.40	4.80
	Qatar	175.80	93.00	–
	Kuwait	128.50	97.00	11.50
	Ghana	68.30	26.40	9.80
	Croatia	62.30	72.20	11.60
	Azerbaijan	47.10	35.20	–
	Jordan	44.20	108.00	13.50
	Cameroon	40.00	20.60	5.10
	Cambodia	25.90	107.70	14.00
	Bosnia	20.20	74.60	10.40
	Madagascar	13.80	25.60	6.80
	Moldova	11.90	43.20	12.80
7.00	India	2,702.90	77.10	7.80
	Italy	2,011.30	–	6.60
	Brazil	1,873.30	96.10	9.40
	Spain	1,394.30	–	6.00
	Australia	1,392.20	123.00	6.20
	Turkey	778.50	58.90	10.70
	Switzerland	725.60	0.00	8.10
	Austria	444.60	0.00	7.10
	Israel	402.50	85.00	7.30
	Ireland	399.30	0.00	11.90
	Singapore	375.50	122.90	8.20
	Colombia	314.50	49.00	9.40
	Chile	278.60	84.20	7.30
	Romania	251.00	41.10	9.30
	Czechia	249.00	83.10	6.80
	Kazakhstan	179.30	35.30	11.90
	Ukraine	153.90	37.90	6.90
	Costa Rico	62.40	46.60	9.60
	Belarus	61.40	35.30	11.50
	Bolivia	40.30	92.50	6.80
	Iceland	24.80	65.30	15.40
	Botswana	16.70	47.20	8.90
	Kyrgyz Republic	8.30	37.20	13.80
	Bhutan	2.50	75.70	13.00

Continuation of Table 1

1	2	3	4	5
8.00	Germany	3,889.70	–	6.30
	United Kingdom	2,857.10	147.70	5.60
	Canada	1,725.30	–	4.80
	Mexico	1,222.40	38.50	9.40
	Poland	596.10	68.40	9.60
	Argentina	487.20	30.40	10.20
	UAE	415.00	92.10	12.30
	Malaysia	358.80	125.10	8.80
	Ecuador	106.20	40.80	11.80
	Kenya	100.40	39.40	12.30
	Dominica	85.60	34.60	9.50
	Georgia	17.50	49.50	11.60
	Armenia	12.60	47.20	12.20

Table 2

Number of observations in each cluster

Cluster	Observations
1	13
2	15
3	21
4	23

Table 3

Analysis of initial cluster centers by factors

Indicators /Clusters	Cluster			
	1	2	3	4
Money supply (% GDP)	0.00	147.70	72.20	30.40
Interest rate on deposit (%)	0.00	0.00	0.00	33.50
Loan interest rate (%)	0.00	0.00	0.00	48.50

Table 4

Analysis of variance

Indicators/Clusters	Cluster		Error		Significance	
	The mean square	Degree of freedom	The mean square	Degree of freedom	F	Importance
Money supply (% GDP)	30,092.415	3	105.775	68	284.49	0.000
Interest rate on deposit (%)	123.353	3	25.111	68	4.91	0.004
Loan interest rate (%)	428.327	3	76.596	68	5.59	0.002

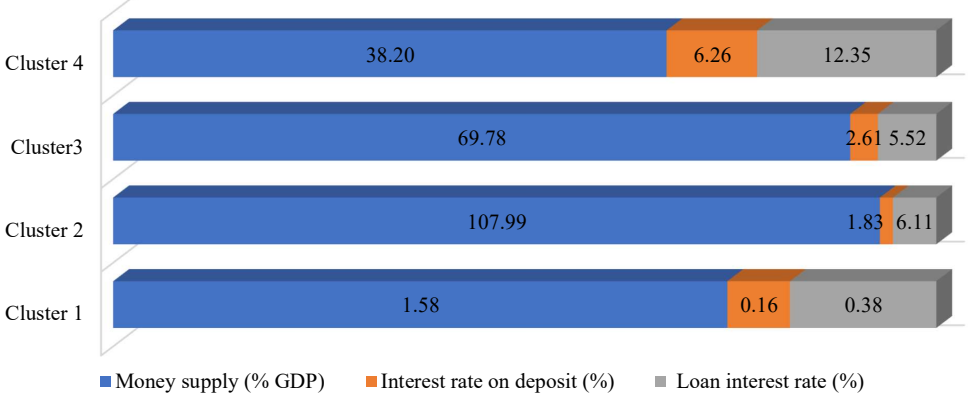

Fig. 1. Global innovation index

Table 5

Analysis of final cluster centers by factors

Indicators/Clusters	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Money supply (% GDP)	1.58	107.99	69.78	38.20
Interest rate on deposit (%)	0.16	1.83	2.61	6.26
Loan interest rate (%)	0.38	6.11	5.52	12.35

5. 2. Analysis of financial stability of countries based on clustering

One of the most common methods of assessing the financial stability of a country - the method of econometric models, namely the multiple regression model – was used for the analysis. Time series analysis (multiple regression method) was used to assess access to credit and the level of interest rates. Calculations were performed using Statistica 12.0 software.

Cluster 1 "Stable Financial Environment": high money supply (% of GDP) reflects stable monetary circulation, such as moderate interest rates on deposits and loans, which indicate a balanced financial policy in countries within this cluster (Table 6).

Cluster 2 "High Access to Credit": normal money supply (% of GDP) with relatively high interest rates on deposits and loans. This cluster is characterized by a more accessible credit market and possibly higher interest rates (Table 7).

Cluster 3 "Limited Access to Credit": low money supply (% of GDP) reflecting a limited amount of money in circulation in countries within this cluster. Higher interest rates on deposits and loans indicate a more restricted access to credit in these countries Table 8).

Table 6

"Stable financial environment": countries in Cluster 1

No.	Countries	Cluster	Distance
1	Germany	1	1.64
2	France	1	1.64
3	Italy	1	2.50
4	Canada	1	1.64
5	Spain	1	1.64
6	Netherlands	1	1.64
7	Switzerland	1	2.79
8	Belgium	1	1.64
9	Austria	1	1.64
10	Ireland	1	1.64
11	Iran	1	1.64
12	Cameroon	1	19.16
13	Cyprus	1	1.64

Table 7

"High access to credit": countries in Cluster 2

No.	Countries	Cluster	Distance
1	United Kingdom	2	40.22
2	Brazil	2	33.76
3	Australia	2	15.04
4	United Arab Emirates	2	17.12
5	Singapore	2	15.02
6	Malaysia	2	17.21
7	New Zeal	2	8.82
8	Qatar	2	15.08
29	Kuwait	2	11.17
10	Jordan	2	2.66
11	Bolivia	2	15.66
12	Nepal	2	12.53
13	Cambodia	2	6.13
14	Barbados	2	6.36
15	Dominica	2	6.04

Table 8

"Limited access to credit": countries in Cluster 3

No.	Countries	Cluster	Distance
1	India	3	8.60
2	Turkey	3	24.01
3	Poland	3	6.26
4	Sweden	3	7.49
5	Norway	3	5.06
6	Israel	3	15.53
7	Denmark	3	9.58
8	Bangladesh	3	14.67
9	Chile	3	14.48
10	Czechia	3	13.67
11	Algeria	3	12.11
12	Bulgaria	3	15.59
13	Croatia	3	6.57
14	Iceland	3	5.39
15	Bosnia	3	5.61
16	Jamaica	3	14.82
17	Mongolia	3	17.18
18	Bahamas,	3	13.70
19	Montenegro	3	11.99
20	Bhutan	3	10.34
21	Belize	3	5.50

Cluster 4 represents "High interest rates" (Table 9). It has a normal money supply (% of GDP) but very high interest rates on deposits and loans. This cluster is characterized by high rates, which may indicate financial difficulties or high inflation in these countries.

Table 9

"High interest rates": countries in Cluster 4

No.	Countries	Cluster	Distance
1	Mexico	4	5.69
2	Argentina	4	45.93
3	Colombia	4	10.96
4	Romania	4	7.69
5	Iraq	4	14.33
6	Kazakhstan	4	14.14
7	Ukraine	4	6.36
8	Ecuador	4	12.79
9	Kenya	4	1.53
10	Dominica	4	3.63
11	Ghana	4	17.86
12	Costa Rico	4	10.25
13	Belarus	4	4.44
14	Azerbaijan	4	6.33
15	Georgia	4	11.98
16	Botswana	4	11.95
17	Benin	4	11.23
18	Madagascar	4	39.28
19	Armenia	4	9.30
20	Moldova	4	6.67
21	Kyrgyz R	4	7.45
22	Burundi	4	6.44
23	Comoros	4	11.91

All identified clusters help to better understand the differences in the financial systems of different countries and their impact on the economy and business. It is important to note that each country has its own specific characteristics and context, so there are additional factors to consider when analyzing financial stability.

5. 3. Correlation and regression analysis of the relationship between the indicators of monetary processes and GDP

After the cluster analysis for the financial stability of countries, it is possible to conduct a correlation-regression analysis. The connection between cluster analysis and correlation-regression analysis lies in the fact that these two methods can be used to analyze data and determine relationships between variables. The results of the correlation and regression analysis are presented in Table 10.

A high level of domestic credit usually corresponds to more active corporate financing and investments, which contribute to economic growth and GDP (Table 11).

In this regression model, using the method of least squares (MLS), the relationship between the GDP variable and two independent variables is estimated: money supply and domestic credit extended by the financial sector (Table 12).

The presented data provides 95 **%** confidence intervals for interpreting variables (Table 13).

The ratios and values of the variables in Table 13 are graphically presented in Fig. 2.

Table 10

Correlation matrix of correlation coefficients between dependent variables and independent variables

Indicators		GDP, billion USD.	Money supply (% GDP)	Interest rate on deposit (%)	Loan interest rate (%)	Bank's capital and assets ratio (%)	Net purchase of financial assets (% GDP)	Credit Information Depth Index (0=low, 8=high)	Domestic credit provided by the financial sector (% GDP)
GDP, billion USD	Pearson correlation	1	0.317**	−0.121	−0.085	−0.023	−0.022	0.203*	0.390**
	Importance (one-sided)	1	0.003	0.149	0.232	0.421	0.424	0.040	0.000
Money supply (% GDP)	Pearson correlation	0.317**	1	−0.121	−0.061	−0.164	0.120	−0.013	0.387**
	Importance (one-sided)	0.003	1	0.149	0.299	0.078	0.152	0.454	0.000
Interest rate on deposit (%)	Pearson correlation	−0.121	−0.121	1	0.636**	−0.037	−0.007	0.144	0.059
	Importance (one-sided)	0.149	0.149	1	0.000	0.375	0.476	0.107	0.305
Loan interest rate (%)	Pearson correlation	−0.085	−0.061	0.636**	1	−0.050	−0.018	0.037	−0.062
	Importance (one-sided)	0.232	0.299	0.000	1	0.334	0.440	0.377	0.297
Bank's capital and assets ratio (%)	Pearson correlation	−0.023	−0.164	−0.037	−0.050	1	−0.007	0.094	−0.104
	Importance (one-sided)	0.421	0.078	0.375	0.334	1	0.474	0.210	0.185
Net purchase of financial assets (% GDP)	Pearson correlation	−0.022	0.120	−0.007	−0.018	−0.007	1	0.069	−0.052
	Importance (one-sided)	0.424	0.152	0.476	0.440	0.474	1	0.277	0.328
Credit Information Depth Index (0=low, 8=high)	Pearson correlation	0.203*	−0.013	0.144	0.037	0.094	0.069	1	0.219*
	Importance (one-sided)	0.040	0.454	0.107	0.377	0.210	0.277	1	0.029
Domestic credit provided by the financial sector (% of GDP)	Pearson correlation	0.390**	0.387**	0.059	−0.062	−0.104	−0.052	0.219*	1
	Importance (one-sided)	0.000	0.000	0.305	0.297	0.185	0.328	0.029	1

*Note: * – the correlation is important at 0.05 (one-sided); ** – the correlation is important at 0.01 (one-sided)*

Table 11

GDP and Credit Information Depth Index and Domestic credit by the financial sec Model results

Indicators	Coefficient	St. error	t-statistics	p-value
const	115.512	1006.44	0.1148	0.9097
Money supply	−110.255	30.7628	−3.584	0.0017
Domestic lending by financial sectors	92.5987	18.5276	4.998	<0.0001

Table 12

Model results

Mean is the dependent variable	1,279.765	St. variance of the dependent variable	4,336.397
The square of the residual sum	1.77e+08	Model st. error	2,899.369
R- square	0.591831	Adjusted R-squared	0.552957
F (2, 21)	15.22461	P-value (F)	0.000082
Logarithm. confidence	−223.7861	Akaike criterion	453.5722
Schwarz's criterion	457.1064	Hannan-Quinn criterion	454.5098

Table 13

Assessment of confidence intervals

Variables	Coefficient	95 % confidence interval
const	115.512	(−1,977.49, 2,208.52)
Money supply	−110.255	(−174.230, −46.2800)
Domestic lending by financial sectors	92.5987	(54.0684, 131.129)

Testing for multicollinearity involves assessing the relationship between independent variables in the model (Table 14). If there is a strong correlation between them, it may indicate an issue of multicollinearity, which distorts regression results and complicates the interpretation of coefficients.

Table 14

Multicollinearity factor diagnostics

lambda	cond	const	Moneysup~	Domestic~
2.68	1	0.039	0.008	0.01
0.285	3.066	0.834	0.018	0.059
0.035	8.813	0.128	0.974	0.931

Based on the provided data, it is possible to see that there may be some correlation between the "Money Supply" and "Domestic Credit Financial sector" variables, but it is not strong and does not cause significant problems with multicollinearity (Fig. 3).

The data set used in the research (Tables 1–14, Fig. 1–3) was compiled on the basis of cluster analysis and correlation-regression analysis according to the source data from the World Bank data [23].

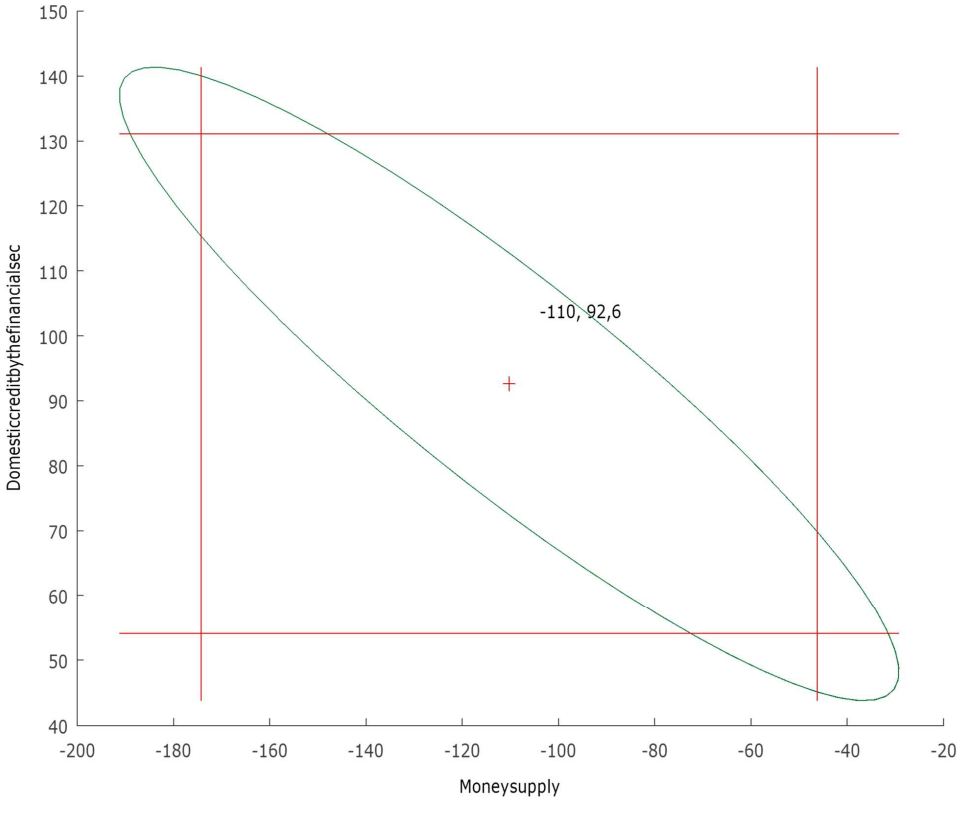

Fig. 2. Confidence interval factors graph

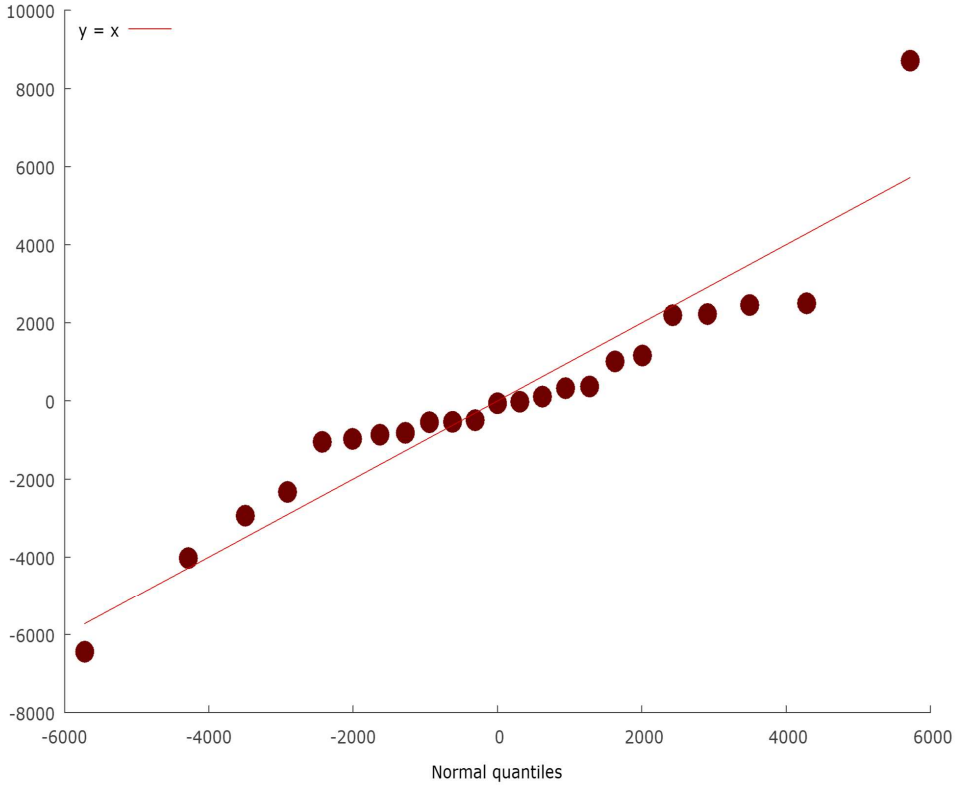

Fig. 3. Quantile plot of the normal distribution

6. Discussion of results of analyzing the impact of monetary processes in the economy on the country's GDP

According to Table 1, countries such as Bangladesh, Iraq, Algeria, Nepal, and others have significantly lower values in terms of GDP, money supply, and the ratio of bank capital to assets. A low level of credit information depth can lead to several consequences:

– difficulty in accessing credit or financial services: In the absence of sufficient credit information, borrowers may face difficulties in obtaining loans or financial services. Banks may deny credit due to uncertainty about the borrower's creditworthiness;

– impediment to the development of the financial system: A low level of credit information depth can hinder the development of the financial system in a country. Banks and other financial institutions may find it challenging to assess risks and offer appropriate financial products and services;

– increased risk and unpredictability for credit organizations: the lack of reliable credit information can lead to a higher risk of default and unpredictability for credit organizations. This can result in a reduction in credit availability and higher interest rates to compensate for risks.

It is worth noting that the level of credit information depth can change over time, and countries can make efforts to improve the accessibility and quality of credit information. This includes the development of credit scoring systems, establishment of credit bureaus, introduction of credit reporting

legislation, and other measures aimed at promoting the development of the credit market and increasing transparency in the financial system.

If the credit information depth index in a country is equal to 7, it indicates a relatively high level of accessibility and quality of credit information in that country. In these countries, credit reporting systems have been developed, and credit institutions have access to extensive information about borrowers and their credit history. Table 1 shows the average GDP, money supply, and bank capital to asset ratios in Turkey, Singapore, Czech Republic, Republic of Kazakhstan, and other countries.

If the credit information coefficient in a country is equal to 8, it means that the level of accessibility and quality of credit information in that country is very high. Germany, Canada, Mexico, Argentina, Armenia, and other countries represented in Table 1 have a well-developed credit reporting system with detailed information about borrowers and their credit history available to credit organizations.

In Table 2, 72 countries are divided into 4 clusters, with 13 countries in the first cluster, 15 in the second, 21 in the third, and 23 in the fourth. For the variables included in the analysis from the Table 3, the money supply (% of GDP) can be analyzed as follows: the initial centers for the 1st cluster are 0, for the 2nd cluster – 147.7, for the 3rd cluster – 72.2, and for the 4th cluster – 30.4 % of GDP. As for the deposit interest rate (%) and the credit interest rate (%), they can be noted in the 4th cluster.

In cluster analysis, the distance between clusters indicates how different or similar two clusters are to each other. It measures the degree of similarity or dissimilarity between clusters based on the selected variables or characteristics.

The distance between clusters can be used for various purposes. Smaller distance between clusters indicates similar characteristics or data similarity between the clusters. This indicates a high degree of similarity between groups of countries or variables. In the process of forming a cluster hierarchy, closer clusters are potentially merged, while more distant clusters may be separated.

In cluster analysis helps evaluate how well the selected variables cluster the countries and allows to identify whether there are statistically significant differences between the clusters based on these variables. All variables included in the cluster analysis, such as money supply (% of GDP), deposit interest rate (%), and credit interest rate (%), were found to be statistically significant (Table 4). This allows to conclude that the differences between clusters are not random.

Cluster 1 "Stable Financial Environment" (Table 6) includes countries such as Germany, France, Canada, Spain, and Switzerland are included. The distance from the cluster center is the smallest – 1.64.

Germany, France, Canada, Spain, and Switzerland are developed countries with well-established financial systems and are typically characterized by a high level of financial stability. These countries have large and reliable banks, strict regulation, and supervision of the financial sector guarantee stability. They are also members of the Eurozone and are subject to certain influences from the overall economic and financial conditions in the region. Stability of the financial system depends on many factors, including the macroeconomic environment, political stability, the effectiveness of regulation and supervision, and measures taken to ensure financial stability. Therefore, while the listed countries are gen-erally considered financially stable, it is important to consider changes in the economic and financial environment.

The 2nd cluster represents "High access to credit" (Table 7). It has a normal money supply (% of GDP) and relatively high interest rates on deposits and loans. This cluster is characterized by a more accessible credit market and possibly higher interest rates.

Countries in this cluster have high credit availability. Banks offer a wide range of credit products, and interest rates on loans are relatively low. This fosters economic and business development, as well as stimulates investment and consumer activity.

Cluster 3 represents "Limited access to credit" (Table 8). It is characterized by a low money supply (% of GDP), indicating a limited amount of money in circulation in the countries of this cluster. Higher interest rates on deposits and loans suggest restricted access to credit in these countries. The banking sector in these countries may be less developed, and interest rates on loans may be higher. This can re-strict opportunities for businesses and investments, especially for small and medium-sized enterprises.

Cluster 4 "High Interest Rates" (Table 9): normal money supply (% of GDP) with very high interest rates on deposits and loans. This cluster is characterized by high interest rates, which may indicate financial difficulties or high inflation in these countries.

In countries within this cluster, the interest rate on credit is higher. The higher rates may be associated with a higher level of risk or constraints within the financial system, which can hinder access to credit and limit investment opportunities.

Correlation analysis helps determine whether there is a statistically significant relationship between variables, while regression analysis creates a model to predict the dependent variable from independent variables.

As can be seen from Table 10, the correlation coefficient of r=0.317** with a significance of 0.03 between GDP and money supply indicates a statistically significant positive relationship between these two variables. In this case, the value of 0.03 means that there is only a 3 % probability that the observed relationship between GDP and money supply is random, in which case it can be concluded that there is a positive correlation between GDP and money supply.

The correlation coefficient of r=0.203* with a significance of 0.04 between GDP and the credit information depth index shows a weak positive relationship between these two variables. The probability of the correlation coefficient and the significance of the observed relationship being statistically significant and not random.

The correlation coefficient (Table 10) r=0.39** between GDP and Domestic credit of the financial sector with a p-value of 0.00 indicates a moderate positive relationship between these two variables. A significance level of 0.00 means that the relationship observed at a significance level less than 0.05 is statistically significant. Domestic credits provided by the financial sector have a significant impact on the gross domestic product (GDP).

Money supply (Table 11): the regression coefficient is –110.099 with a standard error of 31.5102. The t-statistic is –3.494, and the p-value is 0.0023. This indicates a statistically significant negative correlation between the money supply and GDP. Change of money supply per unit is associated with a decrease in GDP by 110.099 units, taking into account other factors in the model.

Domestic credit by the financial sector: the regression coefficient is 92.2861 with a standard error of 19.0526. The t-statistic is 4.844, and the p-value is less than 0.0001.

This indicates a statistically significant positive correlation between domestic credit provided by the financial sector and GDP. Change in domestic credit per unit is associated with an increase in GDP by 92.286 units.

The standard error of the model (Table 12) is 2,968.654, and it shows the distribution of the actual values of gross domestic product relative to the predicted values of the model.

The coefficient of determination (R-square) is 0.592, which means that about 59.25 % of the variation of the dependent variable (GDP) is explained by independent variables used in the model. Adjusted coefficient of determination (adjusted R-square) is equal to 0.531. It takes into account the number of explanatory variables and sample size, and a value close to 1 indicates better fit of the model.

The F-statistic (9.692) is used to test the statistical significance of the overall model. The corresponding p-value (0.0004) is less than 0.05, indicating that the model is statistically significant.

Probability of logarithm reliability (–223.7674) is a measure of how well the model fits the data. The Akaike (455.5348), Schwarz (460.2470), and Hannan-Quinn (456.7849) criteria are used to compare models with different numbers of explanatory variables. Overall, these results indicate that there is a statistically significant relationship between the mon-ey supply and domestic credit, depending on the variables of the financial sector and the GDP variable in this model, $t(21, 0.025)=2.080$.

The presented data provides 95 **%** confidence intervals for interpreting variables (Table 13):

– variable "const": ratio – 115.512. The 95 **%** confidence interval for this variable is –1,977.49 to 2,208.52. This means that with 95 **%** probability, the true value of this variable falls within the specified interval;

– "Money supply" variable: regression coefficient – 110.255. The 95 % confidence interval for this variable is –174.230 to 46.2800. This means that with 95 % probability, the true value of the "money supply" variable falls within the specified range;

– variable "Domestic credit by the financial sec": coefficient – 92.5987. The 95 **%** confidence interval for this variable is between 54.0684 and 131.129. This indicates that with 95 **%** probability, the true value of the "Domestic credit by the financial sector" variable falls within the specified interval. Confidence intervals allow to assess the range of uncertainties and values with a certain degree of confidence (in this case, 95 **%**) for each variable (Fig. 2).

According to BKW (Breusch-Kuhn-Weil test), a condition >=30 indicates a "strong" (close to linear) relationship, while a condition between 10 and 30 is considered "moderately strong". The parameter assesses whether the variance is primarily associated with the problematic situation.

In this case (Table 14), the VIF (Variance Inflation Factor) value for the variable "Money Supply" is 5.852, and for the variable "Domestic Credit Financial sector" it is also 5.852. Both VIF values are less than 10, which means that there may be some correlation between the two variables, but it is not strong. Generally, VIF values between 1 and 5 are considered acceptable and do not indicate serious multicollinearity issues (Fig. 3).

Domestic credit provided by the financial sector positively influences GDP. This indicates that access to credit stimulates economic growth.

However, it is important to remember that the model conclusions are based on the provided data, and the model may have limitations. There could be other factors influencing GDP [24] that are not included in this particular model [25]. So, unlike the study [24] the peculiarity of this study is the use of such factors, the indicators of which are used by the World Bank to analyze financial markets. The distinctive features of the results of this study are the broad sample of countries with different levels of economic development, which is not presented in similar studies [24] and [25].

This study has certain limitations, as not all countries in the world were used in the sample. It is possible to expand the study to include data on other countries in the future.

The disadvantage of this study is the conditionality of clustering using four gradations. The use of more fractional gradations in the development of the study will entail difficulties in the presentation of the results of mathematical processing of data.

7. Conclusions

1. For the variables included in the cluster analysis, the money supply can be analyzed as follows: the initial centers for the 1st cluster are 0, for the 2nd cluster – 147.7, for the 3rd cluster – 72.2, and for the 4th cluster – 30.4 **%** of GDP. The obtained data indicate that in the course of cluster analysis of the variable "money supply" 4 clusters were formed. The initial centers for each cluster reflect the average level of money supply in each group. Cluster 1 has an initial center at 0, which means that this group contains data with minimal or zero money supply. Cluster 2 has an initial center at 147.7, indicating that this group has a higher average level of money supply than the other clusters. Cluster 3 has an initial center at 72.2, indicating that this group has an average level of money supply. Cluster 4 has an initial center at the level of 30.4 **%** of GDP, which may indicate the lowest level of money supply among all clusters. Based on the obtained data, countries can be classified into clusters for further management decisions.

2. 72 countries are divided into 4 clusters, with 13 countries in the first cluster, 15 in the second, 21 in the third, and 23 in the fourth. The first cluster ("stable financial environment") is observed in the smallest number of countries in the sample, followed by the second cluster ("high access to credit"), which is also rare in the world. Countries in the first two clusters have sustained economic growth. Most countries in the sample belong to the third ("limited access to credit") and fourth cluster ("high interest rates"). Economic growth in these countries is slow and requires monetary policy solutions.

3. The correlation coefficient (r=0.317) with a significance of 0.03 between GDP and money supply indicates a statistically significant positive relationship between these two variables. It can be concluded that there is a positive correlation between GDP and money supply. The correlation coefficient (r=0.203) with a significance of 0.04 between GDP and the credit information depth index shows a weak positive relationship between these two variables. The correlation coefficient (r=0.39) between GDP and domestic credit of the financial sector with a p-value of 0.00 indicates a moderate positive relationship between these two variables. A higher level of domestic credit is usually associated with increased financing of enterprises and investments, which contributes to the growth of the economy and GDP. Money supply management and domestic credit should be prioritized in monetary management of the economy.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

Financing

The article has been prepared within the implementation of a project funded by the Scientific Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan, No. AP14871750, titled "Development of innovative products and services as the basis for improving lending in commercial banks in the context of digitization".

Data availability

Data cannot be made available for reasons disclosed in the data availability statement.

Use of artificial intelligence

The authors have used artificial intelligence technologies within acceptable limits to provide their own verified data, which is described in the research methodology section.

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