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Article

Bank lending in Ukraine and simulation of credit activity by methods of system dynamics

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BANK LENDING IN UKRAINE AND SIMULATION OF CREDIT ACTIVITY BY METHODS OF SYSTEM DYNAMICS

The trends of bank crediting of businesses and households in Ukraine are determined and credit interrelations between subjects of economy by means of methods of system dynamics simulated.

The article shows that by end 2020 the main trends in the Ukrainian banking sector are: 1) increasing the dynamics of return on capital, consistently high interest rates on loans until 2019 and their declining dynamics in 2020; 2) declining trends in the dynamics of the share of loans in the assets of commercial banks and the indicator of the financial depth of lending to the Ukrainian economy; 3) predominance of the share of loans to businesses in comparison with the share of loans to households in the loan banking portfolio; 4) faster growth rates of bank loans to households compared to the growth rates of lending to businesses; 5) in the sectoral context, the largest share in lending to business units is accounted for by trade and in lending to households – by consumer lending; 6) half of the loan portfolio of commercial banks are short-term loans for up to one year; 7) the share of non-performing loans in the loan portfolio remains high; 8) gradual reduction of non-deposit sources among the liabilities of commercial banks and their transition to almost full financing at the expense of customer deposits; 9) increase in the share of short-term and decrease in the share of long-term deposit financing of commercial banks.

Based on the methods of system dynamics, the authors created a model that allows to trace the relationship between commercial banks-businesses-households, as well as to calculate the forecast volumes of

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bank loans in accordance with the demand for loans from businesses and households (weighted by the maximum value credit load) and supply of credit resources by commercial banks.

From a practical point of view, determining the characteristic trends of bank lending, modeling the interaction of its main participants and determining the volume of bank loans using system dynamics helps to identify key factors influencing the supply and demand of bank credit resources at the present stage of Ukraine's development and predict future lending dynamics.

Keywords: *commercial banks, bank loans, lending to businesses, household lending, bank deposits, trends in the banking sector, models and methods of system dynamics*

Introduction. One of the basic tools to facilitate the country's economic development is bank lending. Access to credit resources by business and households contributes to the revival of business activity and economic growth. Therefore, it is relevant and important to characterize the trends of bank lending to businesses and households in Ukraine, assess the structure and dynamics of credit services and factors of demand / supply of credit resources. This is necessary to understand the current relationships and future dynamics of lending activity, their impact on the banking system and the course of economic processes in Ukraine in general.

It should be noted that there is a large number of fundamental and applied works on the subject of bank lending. This issue is the subject of research by such Ukrainian authors as: M. Savluk, A. Moroz, M. Pukhovkina, S. Naumenkova, S. Mishchenko, V. Lagutin, V. Kozyuk, V. Korneev, A. Peresada and others. (Naumenkova, 2014; Davydovych, 2017). Their works highlight the basic issues regarding the nature of credit and the credit market; existing types and forms of lending at the national and global levels; sources of origin and ways to minimize credit risks; activities and regulation of financial stability of the banking system as a whole, etc.

On the other hand, the bank lending sector is the object of applied analytical research, including by such authors as S.O. Korablin, N.Ya. Yurkiv, D.M. Gladkikh, V.M. Kremen, O.I. Flint, L.P. Gulyaeva, O.S. Irshak, I.Y. Leschuk, G.M. Zabchuk, Y.V. Zhezherun and others. (Korablin, 2019; Yurkiv, Hladkykh, 2019; Irshak, Leschuk, 2018; Zhezherun, 2019). Their publications consider the state of bank lending to the real sector, its development and its impact on the development of Ukraine's economy; the current state of bank lending to households, identifying risks and prospects for its development in Ukraine; risks and insecurity of creditors and borrowers in the Ukrainian legislative field, etc.

At the same time, the banking sector in a market economy is dynamic in nature, which means that it makes sense to monitor trends in its operation in any period of economic development, since the challenges, goals, and priorities constantly change.

Also, taking into account the variability of economic development in general, and the banking sector, in particular, modeling and forecasting the dynamics of growth/ decline of bank lending should also be developed, including by deepening the

existing methods and by introducing new forms and methods of modeling and assessment of the situation in the sector.

Main findings. To assess the state of bank lending in Ukraine in recent years, consider the main trends in the banking sector.

First of all, during 2014-2016, the banking system of Ukraine underwent significant restructuring. While at the beginning of 2014 there were 180 commercial banks, then at the beginning of 2021 there were 73 (see Fig. 1). In 2014-2020, 107 commercial banks were withdrawn from the financial market to clean the banking system of insolvent banks and banks with non-transparent activities. Such a policy of the NBU had a positive impact on the banking sector in terms of its quality, transparency and financial stability in the long run.
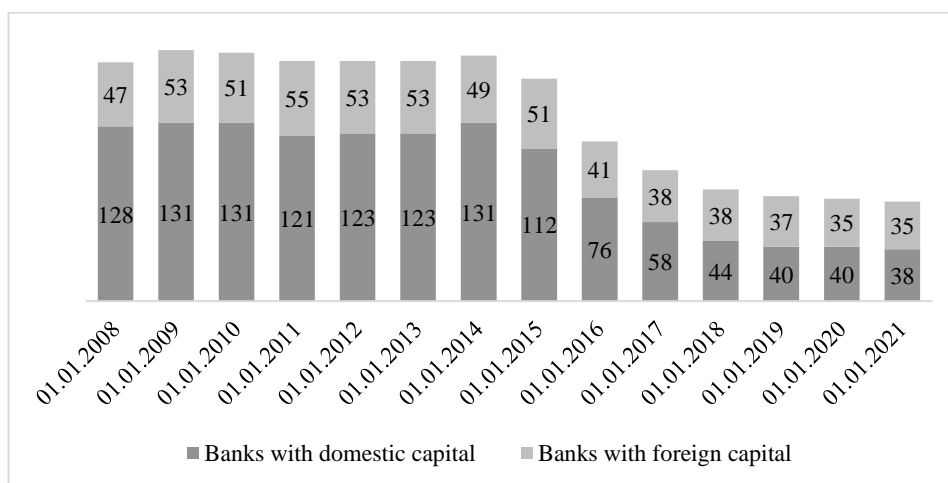

Figure 1. The number of commercial banks in Ukraine from 2008 to 2020
Source: National Bank of Ukraine (https://bank.gov.ua/).

It should also be noted that at the beginning of 2014, the share of banks with domestic capital was 73% and, respectively, with foreign capital - 27%, while at the beginning of 2021 this ratio was 52% and 48%, respectively. This indicates a decrease in the competitiveness of banks with domestic capital due to low capitalization, limited access to financial resources, and weakening positions in lending. To some extent, this was due to the increased vulnerability of the Ukrainian financial sector to political and economic instability in Ukraine and external shocks.

Second. With the exception of the recent two years (by 2018) there was a growing trend of nominal lending in the Ukrainian economy. Among the assets of commercial banks, loans accounted for a significant share - from 78% to 70% by 2015, and during 2015-2020, their share began to decline and in 2020 amounted to 43% of all bank assets. (Fig.2). At the same time, the shares of bank deposits and investments in securities other than shares grew.

It should also be noted that since 2009 the rate of creditworthiness of the Ukrainian economy (financial depth) has been declining. This was observed both for the indicator as a whole and in terms of both the share of loans to businesses and the share of loans to households in relation to GDP (Table 1).

Figure 2. Dynamics of bank loans in 2006-2020

Source: National Bank of Ukraine (https://bank.gov.ua/).

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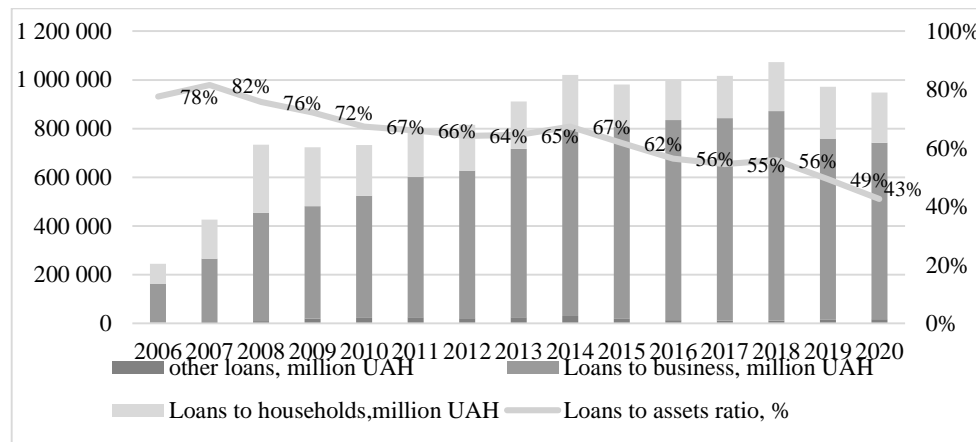
Table 1

The share of loans in the GDP of Ukraine, including in terms of lending to businesses and households during 2006-2020

Period	Total loans, *million UAH*	Loans to business, *million UAH*	Loans to households, *million UAH*	GDP, *million UAH*	Financial depth, *%*	Financial depth for business, *%*	Financial depth for households, *%*
2006	245 230	160 503	82 010	565 018	43.40	28.41	14.51
2007	426 867	260 476	160 386	751 106	56.83	34.68	21.35
2008	734 022	443 665	280 490	990 819	74.08	44.78	28.31
2009	723 295	462 215	241 249	947 042	76.37	48.81	25.47
2010	732 823	500 961	209 538	1 079 346	67.90	46.41	19.41
2011	801 809	575 545	201 224	1 299 991	61.68	44.27	15.48
2012	815 142	605 425	187 629	1 404 669	58.03	43.10	13.36
2013	910 782	691 903	193 529	1 465 198	62.16	47.22	13.21
2014	1 020 667	778 841	211 215	1 586 915	64.32	49.08	13.31
2015	981 627	787 795	174 869	1 988 544	49.36	39.62	8.79
2016	998 682	822 114	163 333	2 385 367	41.87	34.46	6.85
2017	1 016 657	829 932	174 182	2 983 882	34.07	27.81	5.84
2018	1 073 131	859 740	201 102	3 560 596	30.14	24.15	5.65
2019	971 871	744 648	212 515	3 978 400	24.43	18.72	5.34
2020	948 386	724 157	206 471	4 194 102	22.61	17.27	4.92

Source: National Bank of Ukraine (https://bank.gov.ua/).

The structure of loans of commercial banks (see Fig. 2, Table 1) shows that loans to businesses significantly outweigh the volume of loans to households. Thus, in 2007, the loan portfolio of commercial banks consisted of 61% loans to businesses, 37.6% those granted to households and 1.4% other loans. As of the end of 2019, 76.6% of all loans were given to businesses, 21.9% were loans to households and 1.5% – other loans. In general, this indicates that lending to legal entities is an essential component in lending operations of Ukrainian commercial banks.

Despite the fact that business loans significantly predominate in the loan portfolio of commercial banks, net hryvnia loans to households grew faster than loans to businesses during this period. In particular, during 2017-2019, their growth rates fluctuated at about 30% y/y. At the same time, it should be noted that in December 2020, this indicator slowed down to 5.5% y/y, and as of March 2021, the increase was + 8.2% y/y. Also, the robust demand for these loans allows commercial banks to lower interest rates on them more slowly, while net hryvnia loans to businesses decreased by 6.2% in 2019 (Review of the banking sector of the National Bank of Ukraine, 2020).

Third, in the context of loans' maturity (see Fig. 3), it is clear that in 2006-2020, in the overall structure of credit portfolio, the share of medium-term and long-term loans decreased, while the volume of loans issued for up to 1 year, on the contrary, increased. Thus, in 2007 short-term loans accounted for 31% of total loans, while at the end of 2020 the figure increased by 18 percent and accounted for 49%. As for loans with a term of 1-5 years, their share in 2007 was 42%, and in 2020 – 33%. The share of long-term loans with a term of more than 5 years also decreased from 27% in 2007 to 18% in 2020. This trend indicates an increase in demand for credit resources to meet the current needs of businesses and households. Instead, demand for medium- and long-term loans declined.
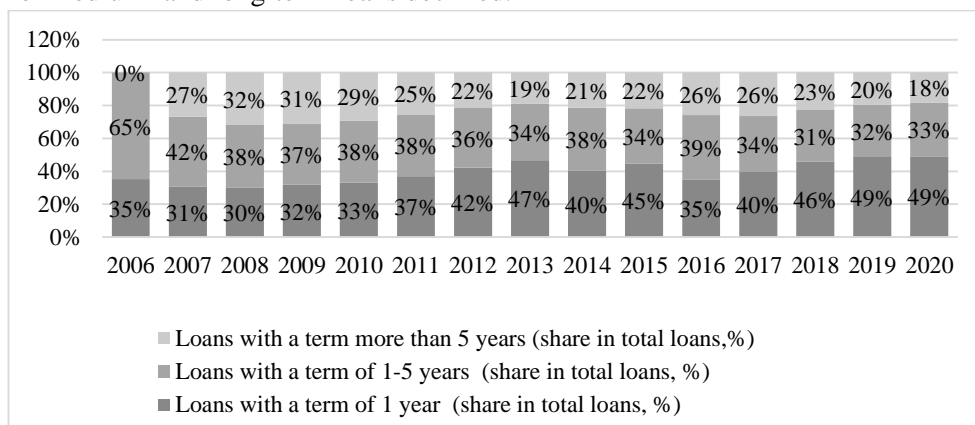
Figure 3. Dynamics of bank loans by loan terms in 2006-2020

Source: National Bank of Ukraine (https://bank.gov.ua/).

Fourth, the structure of bank loans in foreign currency (see Figure 4) shows that the share of loans in national currency increased from 50% in 2006 to 63% in 2020, and the share of loans in foreign currency decreased from 50% in 2006 to 37% in

2020. It is noticeable that in the crisis periods - in 2008 and 2015 - the share of loans in foreign currencies increased sharply due to the devaluation of the national currency. Volatility of the exchange rate carries a high currency risk and affected the essential fluctuation in demand for foreign currency loans. In addition, the NBU banned loans to individuals nominated in foreign currency.
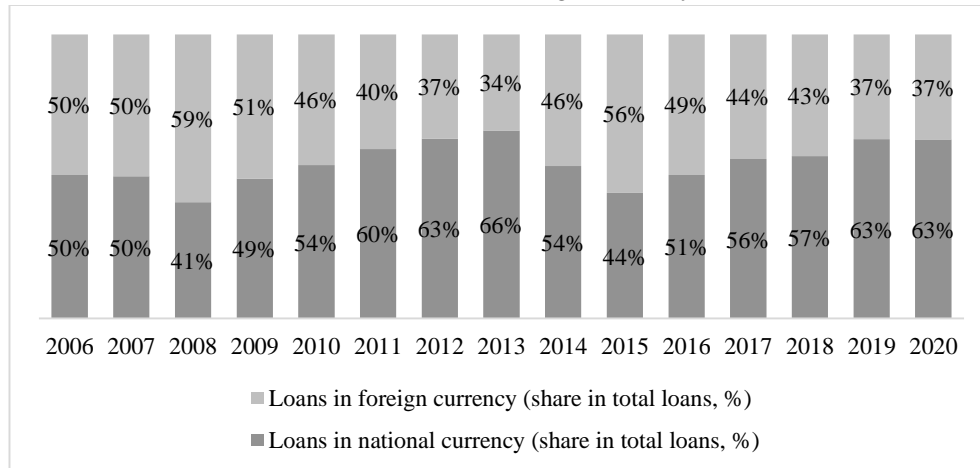

Figure 4. Dynamics of bank loans by loan currency in 2006-2020

Source: National Bank of Ukraine (https://bank.gov.ua/).

Fifth. In terms of the structure of bank loans granted to businesses by industries (Fig. 5), the following conclusions can be made. As of March 2021, the largest amount of credit funds was concentrated in the field of wholesale and retail trade (36% of all business loans); 23% of all loans to businesses are concentrated in manufacturing. Agriculture, forestry and fisheries account for 8% of all loans; electricity, gas, steam and air conditioning and operations - 10%; real estate transactions - 7%; transport, warehousing, postal and courier activities - 5%; the construction sector - 3%; and 1% are accounted for by financial and insurance activities and by information and telecommunications.
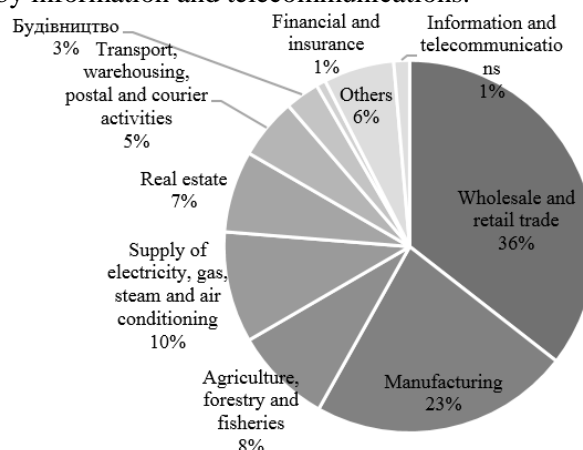

Figure 5. The structure of bank business loans by economic activities in March 2021

Source: National Bank of Ukraine (https://bank.gov.ua/).

The dynamics of lending to businesses by industries shows that in recent years, loans have been mainly concentrated in almost the same sectors (Table 2).

Table 2

**The structure of bank loans to businesses by activity,** *%*

Activity	2014	2015	2016	2017	2018	2019
Wholesaling and retailing*	32.97	32.3	32.23	32.9	33.29	37.67
Agriculture, hunting and related services	7.04	6.11	6.70	7.10	7.83	7.57
Food processing	5.95	6.56	6.77	6.95	7.76	7.84
Real estate	8.98	9.56	9.88	8.60	7.75	7.03
Supply of electricity, gas, steam and air conditioning	4.28	3.99	4.84	6.30	6.71	7.55
Housing construction	6.32	4.58	4.25	3.93	3.41	2.08
Chemicals	3.06	2.53	2.36	2.70	3.24	2.87
Land and pipeline transportation	2.41	2.89	2.76	2.53	2.93	2.03
Metallurgy	3.20	4.28	4.63	3.64	2.57	2.3
Other	21.68	22.22	21.37	19.67	19.29	21.59

* except for motor vehicles and motor vehicles and motorcycles dealership.

Source: National Bank of Ukraine (https://bank.gov.ua/).

It should be noted that the share of loans for construction decreased significantly - from 6.3% in 2014 to 3% in 2020, while the volume of loans for food production increased from 6.0% to 7.8% in 2014 and 2019, respectively, and the volume of loans for the supply of electricity, gas, steam and air conditioning increased from 4.3% in 2014 to 10% in 2020.

Sixth. The structure of bank loans to households by target shows that during 2006-2020 the predominant share was accounted for by consumer loans. There was a trend of increasing their share from 57% to 83% in 2020 (Fig. 6)
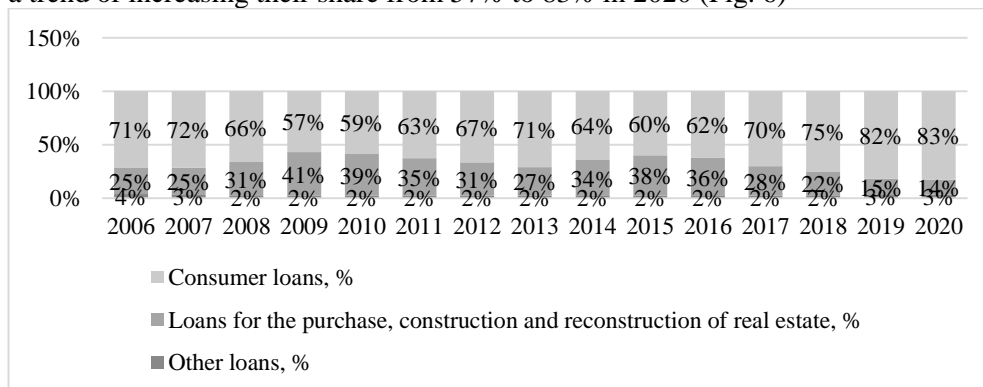
Figure 6. Structure of bank loans to households in 2006-2020

Source: National Bank of Ukraine (https://bank.gov.ua/).

The other part was occupied by loans for purchase, construction and reconstruction of real estate - 25% in 2006 and 14% in 2020. The dynamics of the share of mortgage loans to households in Ukraine is shown in Fig. 7.
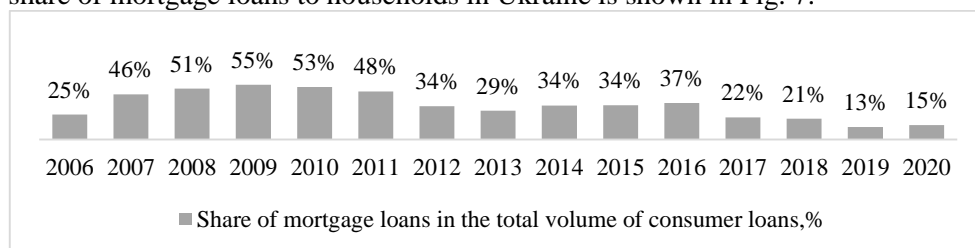

Figure 7. Dynamics of the share of mortgage loans in total volume of consumer loans in 2006-2020

Source: National Bank of Ukraine (https://bank.gov.ua/).

We see that in recent years the volume of mortgage lending has been declining. The share of mortgage loans in the total volume of loans to households was 15% in 2020, while, for example, in 2009 this figure was 55%. Moreover, the ratio of the mortgage portfolio in hryvnia to GDP is less than 1%, and, according to market participants, mortgages financed less than 7% of transactions (Report on financial stability, 2019). The reasons for such a low share of mortgage lending include: the shortage of solvent borrowers with officially confirmed income; insecurity of individuals investing in housing in the primary market; slow decline in mortgage interest rates, in particular, in December 2020, the average mortgage rate on the secondary housing market was 14%, and on the primary market - 16.9% (Mortgage rates continued to decline in January - bank survey results, 2021). However, despite the low share of housing mortgages in retail lending, it should be noted that the growth rate of real estate loans in 2020 increased faster than consumer loans: + 11.5% y/y at the end of December 2020.

In the context of the characteristics of the bank loans market in Ukraine, we will also note the trends in the performance of the banks themselves, as they affect the supply of loans to the economy.

First. It should be emphasized that in 2019, commercial banks operated with increasing profitability, which was the highest for the entire period of activities of the banking sector [8]. This trend took place because the return on the banks' capital increased during 2017-2019 and in 2019 was exceeded 30% (see Figure 8). During this period, operating income grew by 41.7% y/y and operating expenses by only 10.7% y/y. Another factor of the sector's record profit was the currency revaluation of the result of trade operations of state-owned banks.

In 2020, the upward trends of profitability reversed, and by the end of 2020, this indicator decreased to 19.2%. This is still a high figure, despite such a decline, provoked by the recession in the world and in Ukraine over the past 2 years in the pandemic COVID-2019 crisis.
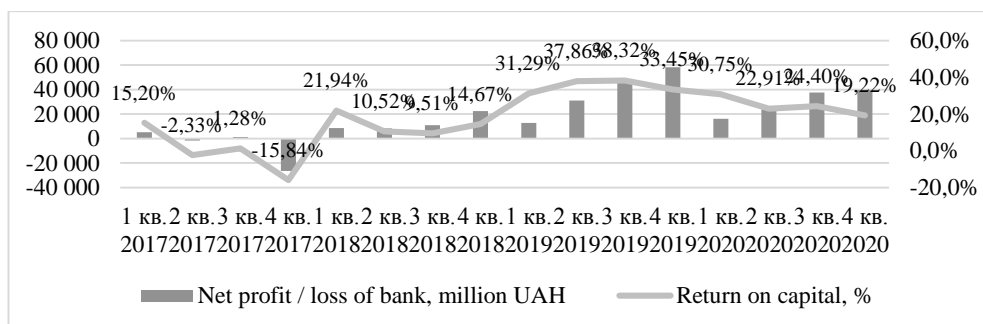
Figure 8. Dynamics of net profit/loss of banks and return on capital in 2017-2020

Source: National Bank of Ukraine (https://bank.gov.ua/).

Second. The following trends were observed in the cost of loans and deposits in the banking sector. In recent years, until 2019, the weighted average cost of credit resources fluctuated at 14-17% per annum, and the cost of deposits at 7-11.5% (Fig. 9). There was no decrease in interest rates on loans due to high credit risks of borrowers and their low solvency, small number of reliable borrowers and profitable projects, and limited long-term financing of commercial banks, as there was a tendency to open short-term deposits and demand deposits. (Manzhos, 2016).
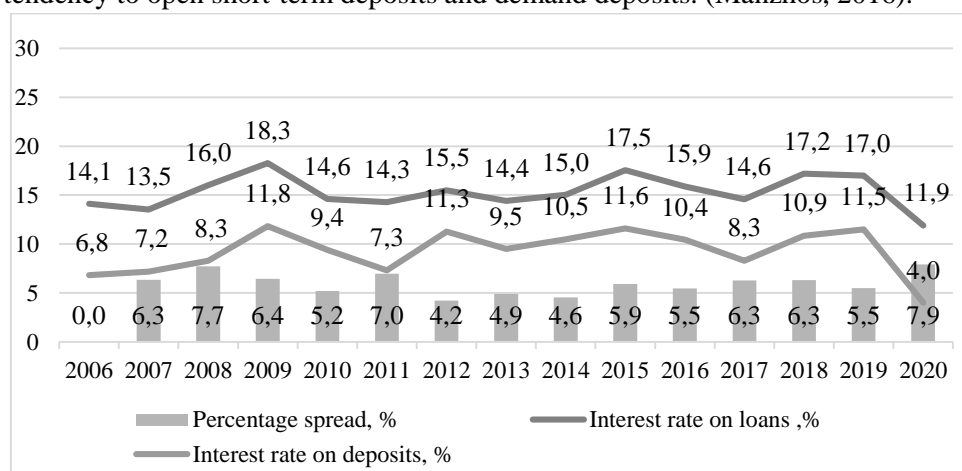
Figure 9. Dynamics of interest rates on loans and deposits, interest spread and discount rate of the NBU in 2006-2020

Source: National Bank of Ukraine (https://bank.gov.ua/).

From 2019, the discount rate of the NBU began to decrease (to 6% by mid-2020). Accordingly, interest rates of commercial banks on deposits and loans also began to decline. It should be noted that in 2020 the deposit rates decreased significantly more than did the credit rates, which means that so far the interest spread (margin) remains at a level usual for the banks. However, given that the benchmark for the monetary policy and development of the credit sector still consists in the cheaper bank loans, the result may be a decrease in this margin and reduced profitability of the banking sector in the medium term (Review of the banking sector of the National Bank of Ukraine, 2020).

Third. In the context of the provision of commercial banks with borrowed resources, one should consider the ratio of loans to businesses and households and deposits attracted from them as the main source of the banks' lending activity (see Figure 10).
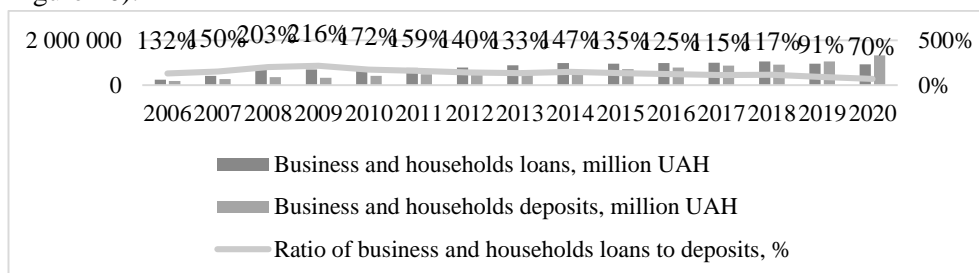

Figure 10. The ratio of loans to business and households to deposits attracted from them in 2006-2020

Source: National Bank of Ukraine (https://bank.gov.ua/).

As can be seen from Figure 10, during 2006-2018, the volume of loans granted by commercial banks exceeded the volume of attracted deposits. There was a situation of a constant lack of borrowed funds to cover their own lending activities, and the use of other (non-deposit) sources of funding. During this period, along with the financing of commercial banks through deposits of individuals and legal entities, a significant share in the structure of their liabilities were the funds provided in the interbank market and by international financial organizations (IFOs). In particular, in 2008, their share reached 39%, but during this period it decreased to 8% by the beginning of 2020 (Trends in the banking sector. Practical aspects of bank risk assessment: seminar for university professors of Ukraine, 2020). From 2019-2020, the ratio of loans and deposits is 91-70%, which indicates an excess of deposits over loans and is evidence of the provision of commercial banks with sufficient financial resources for lending activity.

Fourth. The general dynamics of deposits attracted by commercial banks from business entities and households during 2006-2020 increased, and their share in the liabilities of commercial banks also increased - from 51% in 2006 to 84% in 2020 (Fig. 11)
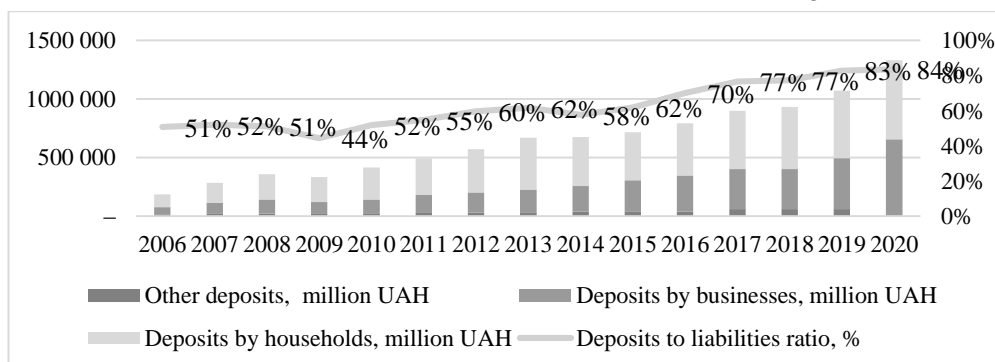

Figure 11. Dynamics of the volume of deposits attracted by commercial banks in 2006-2019

Source: National Bank of Ukraine (https://bank.gov.ua/).

However, despite the growing dynamics in the ratio of loans to deposits and the share of deposits in the banks' liabilities, it is worth paying attention to the qualitative characteristics of the deposit security of commercial banks.

In particular, in terms of maturity in the structure of deposits, the following trends were observed:

- increase in the share of demand deposits and deposits up to 1 year. At the end of 2020, they reached 60% and 29% of all attracted deposits, respectively;

- reduction of deposits for a period of 1-2 years and more than 2 years. At the end of 2020, their shares decreased to 10% and 1% of all attracted deposits, respectively (Table 3).

This situation is explained, among other things, by inflationary and devaluation expectations of households and business, in case of whose aggravation, the entities retain the opportunity to withdraw savings from the banking sector and convert them, for example, into foreign currency, which, in turn, poses a constant threat to the currency channel of monetary policy and exchange rate stability in the country.

Table 3

Structure of commercial banks' deposits, by maturity terms, *%*

Period	Total deposits, *million UAH*	By maturity terms, *%*			
		demand deposits	deposits up to 1 year	deposits 1-2 years	deposits more than 2 years
2007	283875	33	21	37	8
2008	359740	30	26	34	10
2009	334953	36	40	18	6
2010	416650	37	32	26	6
2011	491756	36	31	27	6
2012	572342	32	33	29	6
2013	669974	31	28	37	4
2014	675093	37	31	28	4
2015	716728	43	38	17	3
2016	793475	46	34	19	1
2017	898844	47	33	17	4
2018	932967	49	35	13	3
2019	1071666	55	33	10	2
2020	1 348 130	60	29	10	1

Source: National Bank of Ukraine (https://bank.gov.ua/).

Fifth. The share of non-performing loans in the total volume of issued bank loans remains quite high, although in recent years their level has slightly decreased (Fig. 12).

Figure 12. The share of non-performing loans in total loans in 2017 - early 2020

Source: National Bank of Ukraine (https://bank.gov.ua/).

Thus, as of the beginning of August 2017, the share of non-performing loans was 57.99%, having decreased by 9.24 percentage points to 48.75% at the end of 2019. The share of non-performing loans of economic entities has a downward trend, but fluctuates at 56% during the period under analysis. The share of non-performing household loans is declining at a faster pace, from 63% in 2017 to 34% at the beginning of March 2020.

The positive dynamics of the decrease in the level of non-performing loans can be explained by the decrease in the volume of non-performing foreign currency loans, the "blurring" of the loan portfolio with new loans and the restructuring of some loans to businesses. It should be noted that almost all non-performing loans were issued by commercial banks before 2015 and the level of their coverage by credit reserves was 93.8% at the end of 2019. Due to this, non-performing loans on banks' balance sheets do not carry significant risk for commercial banks, so this does not create significant restrictions on the potential volume of new loans.

It should be noted that in order to turn loans into one of the key drivers of the country's economic development, it is important to identify the determinants of the impact on loans from supply and demand based on credit relations between commercial banks, businesses and households.

Based on the application of methods of system dynamics, the authors developed a simplified model that reflects in a generalized form the demand for bank loans from businesses and households and the ability of commercial banks to meet this demand, reflects the links between these entities and can be used to calculate and forecast the amounts of bank loans.

System dynamics is the modeling of the nonlinear behavior of various complex systems over time (public finance, banking, social systems, etc.), which demonstrates the interaction between objects in the system. System dynamics was developed in the mid-20th century at the Massachusetts Institute of Technology by professor J. Forrester (Forrester, 2007) and his followers.

The system dynamics apparatus makes it possible to model and formalize causal linear and nonlinear relationships in complex socio-economic and financial systems in different regimes by building direct and inverse relationships. Feedback systems in system dynamics (simulation modeling) are treated as endogenous structures, where the behavior of each of the variables of the system is produced by other variables of the same system (Bala, Arshad, Noh, 2017).

The basic elements of system dynamics models are:

a) *stocks* - the accumulation of certain elements, for example, goods, materials, information etc. The stock is the main element of the system dynamics model. It accumulates information, physical or intangible resources, and also changes in time through the flow. The flow, in turn, shows the change that has occurred in the stock per unit of time. In other words, a stock has 'memory' and changes gradually;

b) *flows* reflect the change in the level of the stock, which was initiated endogenously in a closed system;

c) *feedback loops* and *converters* - a closed network of cause-and-effect relationships with a system of rules for making decisions and actions that have a significant impact on basic elements, in particular stocks (Sterman, Burr, Ridge, Dubuque, Madison, 2000). A converter is a model element that directly affects only the flow, thereby determining its functional form - linear or nonlinear (Wheat, 2007). There are two types of feedback systems - positive feedback loops and negative feedback loops. A positive (amplifying) feedback loop generates exponential growth, while a negative (balancing) loop brings the value of the variable closer to a certain target level (Lukianenko, Novik, 2018).

Specialized software packages for simulation modeling allow displaying clearly in a graphical form the interaction of elements within the system under study. It facilitates the perception of systems and their practical application. The graphical display of models is supplemented by their mathematical representation since system dynamics is inherently a quantitative research method, which is based on systems of differential equations (Wheat, 2007).

For example, let's consider the simplest structure of the stock change process, where $Stock_t$ denotes a certain notional stock in the time period *t*, *Inflow* and *Outflow* are the input and output flows, respectively, *Converter 1*, *Converter 2* are constants that determine the change in flows. According to the notation introduced above, the stock change process can be represented by the system of mathematical equations:

$$\begin{cases} Stock_t = \int_{t_0}^{t} (Inflow_s - Outflow_s)ds + Stock_{t_0}; \\ Inflow_s = Converter1(const); \ Outflow_s = Converter2(const); \end{cases}$$

where *t* is the time period, *ds* is the time interval between the recalculations of the model stock value.

The above system of equations is simple and therefore does not contain a feedback loop. That is, the stock change is assumed only through flows, without taking into account the influence of the current stock level. To describe the behavior

of more complex realistic processes, simulations are performed using feedback loops that allow for bi-directional relationships between model variables.

So, system dynamics allows to recreate the structure of the selected system, and to evaluate and predict its behavior.

The constructed system dynamics model presented below consists of three economic sectors where credit relations happen: 'Business entities', 'Households', and 'Commercial banks'. To understand the features of the model, we will consider and analyze each sector in detail, identifying the model's parameters, the relationships between the elements and the behavior of the model as a whole (see Appendix A).

Fig. 13-14 highlight sectors for the formation of demand for loans from businesses and households.
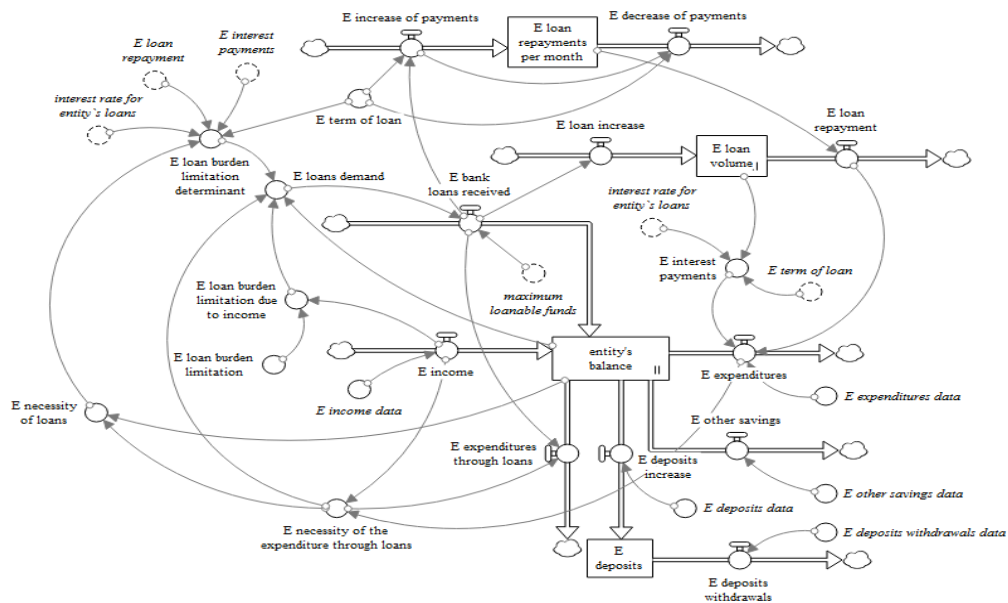

Figure 13. "Business" sector of the bank loans market model using system dynamics methods

Source: compiled by the authors.

The basis of the sectors 'Business entities' and 'Households' of the model is the stock variable "Balance of business entities (households)", which shows the balance of money and increases due to the inflows: income of business entities (households) and bank loans received. And, accordingly, it decreases due to the outflows: costs incurred through own and credit money, deposits at commercial banks and other savings. Income and expenditures made by own money, as well as the volume of deposits and other savings are determined on the basis of exogenous variables (monthly time series of income and expenditure of businesses and households). Instead, flows such as bank loans received and expenditures by loans occur when there is a demand for bank loans.
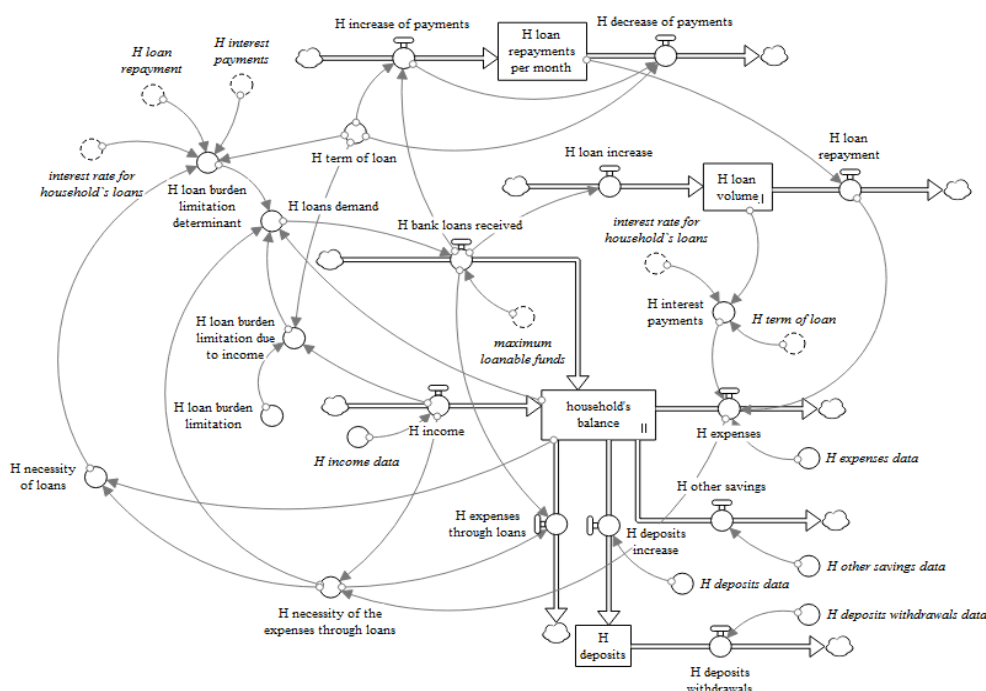
**Figure 14. "Household" sector model of bank loans market using the
methods of system dynamics**

Source: compiled by the authors.

According to the model's assumptions, if the received income is smaller than the expected expenditures, there is a need to get loans, which is determined by the difference between income and expected expenditures. The actual volume of demand for loans is determined taking into account the maximum value of the credit load. In the model, this indicator is a constant and expresses the maximum allowable ratio of the expected loan to equity for businesses, and for individuals – the maximum ratio of the expected loan to the average monthly salary weighted for the term of the loan. Accordingly, the amount of bank loans received is calculated according to the demand for loans, taking into account the fact that it does not exceed the maximum loan load and taking into account the maximum allowable supply of loans by commercial banks (which will be discussed later). In case of excess, the amount of loans is equal to the supply of loans (lending base).

Thus, the amount of borrowed loans determines the total volume of loans (stock variable). Interest expenses for loans, which are included in total expenses, are determined on the basis of the amount of borrowed loans, the interest rate on the loan and its term. In addition, according to the amount of loans received and the term of the loan, the amount of monthly installments on loans (repayment of the loan body) is calculated.

In the context of the "Commercial Banks" sector, we perform modeling on the basis of a simplified version of the bank's balance sheet (see Fig. 15):
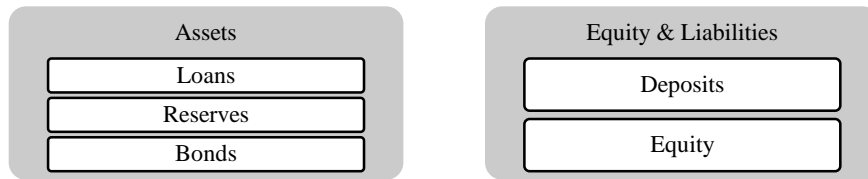
Figure 15. Simplified balance sheet of a commercial bank

According to the simplified balance sheet of the bank, this segment of the model can be divided into two parts: the left part reflects the assets of a commercial bank, and the right one – its liabilities (see Fig. 16).
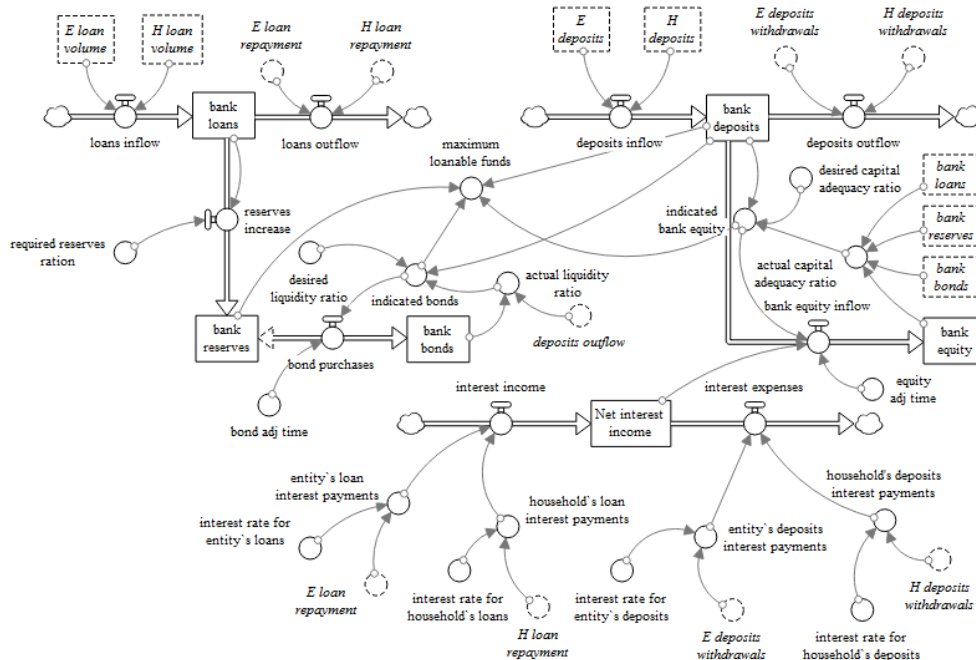

Figure 16. "Commercial banks" sector model of bank loans market using the methods of system dynamics

Part of the assets is represented by three stock variables: "Volume of loans", "Bank reserves" and "Volume of bonds", which we will consider in more detail. First of all, the value of the stock variable "Volume of bank loans" is determined: it increases due to the inflow (increase in loans) and decreases due to the outflow (the amount of repaid loans). These indicators are defined in the segments "Business" and "Households". Also, the stock variable "Bank reserves" reflects the amount of required reserves for the activities of banking institutions. Since commercial banks are required to maintain bank reserves in accordance with the NBU-established level, it was assumed that the reserves are defined as the amount of borrowings multiplied by the mandatory reserve ratio set by the NBU. In addition, the stock variable "Volume of bonds" is subject to adjustment to ensure the required level of liquidity

of commercial banks. The model simplifies that the actual level of liquidity is calculated as the ratio of the expected outflow of deposits to the volume of bonds. Accordingly, if this indicator is smaller than the established regulatory level of liquidity, part of the funds raised by banks in the form of deposits goes to the purchase of commercial banks bonds (volume of deposits multiplied by the difference between the regulatory and actual value of liquidity).

Part of the liabilities is represented by two main stock variables: "Volume of deposits" and "Volume of equity". The stock-variable "Volume of attracted deposits" is determined by analogy with the stock variable "Volume of loans" in terms of assets: increases due to the inflow (an increase in attracted deposits) and decreases due to the outflow (the amount of deposits paid). These indicators are also defined in the segments "Business" and "Households". For simplicity, the stock variable "Equity" is growing due to the net interest income. In addition, it is assumed that the amount of equity is further adjusted according to the capital adequacy ratio. Its actual level is defined as the ratio of equity to net assets of the bank (loans and bonds minus reserves). Accordingly, if the actual capital adequacy ratio is less than standard, then part of the funds raised by banks in the form of deposits is redirected to the capital of banks (volume of deposits multiplied by the difference between the regulatory and actual value of capital adequacy).

Thus, the maximum allowable amount of loans that can be provided by commercial banks (loan offer) is defined as the difference between attracted deposits (minus the part of deposits that goes to the purchase of bonds and equity formation) and reserves.

In addition, it should be noted that in the "Commercial Banks" sector there is a stock variable "Net interest income" (which was mentioned earlier as a determinant of growth of the stock variable "Equity"), which is defined as the difference between interest income and costs. Accordingly, interest income is defined as the amount of interest payments received for the use of loans from businesses and households. Then, the interest expenses of commercial banks consist of interest payments on deposits to businesses and households. This sub segment makes it possible to further investigate the effectiveness of the use of borrowed funds by commercial banks and the effectiveness of their lending activities.

Thus, the model makes it possible to trace the relationship between commercial banks and business and households. The volume of bank loans is calculated in accordance with the demand for loans (sectors "Business" and "Households"), weighted by the maximum amount of credit load, provided that this amount does not exceed the maximum allowable lending base defined by commercial banks (sector "Commercial banks»).

Conclusions. At the end of 2020, the following was observed in the banking system of Ukraine.

1. Almost half (48%) of the banking sector is banks with foreign capital.

2. The banking sector was characterized by growing dynamics of return on capital (more than 30%) and consistently high interest rates on loans until 2019 and

declining dynamics of bank interest rates on deposits (up to 4%) and loans (up to 11.9%) in 2020.

3. The share of loans in the assets of commercial banks and the indicator of the financial depth of lending to the Ukrainian economy had a downward trend. In particular, the share of bank loans in relation to the country's GDP decreased from 76.37% in 2009 to 22.61% at the beginning of 2020. The share of loans in assets of commercial banks decreased to 43% in 2020 from 82% in 2008.

4. The structure of the bank loan portfolio by borrowers had the following characteristics:

- the predominance of loans to business (76.6%), while loans to households account for 21.9%;

- among loans to business, the main share falls on credits for trade (36% of the loan portfolio);

- loans to households are growing faster (+ 29.8% in 2019) compared to lending to business;

- short-term consumer loans predominate among loans to households (82%) and mortgages account for 15%.

5. In the context of term of loans, half of the commercial banks loan portfolio (49%) are short-term loans (up to 1 year).

6. In the context of the quality of commercial banks loan portfolios, the share of non-performing loans in the total volume of issued loans remains quite high - up to 48.75%. In the segment of loans to business, this indicator is at 56% of total, and in the segment of loans to households - at 34%.

7. In the context of sources of financing of commercial banks, the following was observed:

- growing dynamics in the ratio of loans to deposits, lack of borrowed funds to cover their own lending activity, and the use of other, non-deposit, sources of funding (interbank market and IFOs). Only from 2019 the ratio of loans to deposits changed. In 2019 it was 91% and in 2020 - 70%, which is evidence that banks have almost fully started to be financed by customers;

- growing dynamics in the short-term financing and declining dynamics in the long-term financing of commercial banks. By the beginning of 2020, there was an increase in the share of demand deposits and deposits with original maturity of up to 1 year - they reached 60% and 29% of all attracted deposits, respectively. Along with this, there was a reduction in the share of deposits with a term of 1-2 years and more than 2 years - by the end of 2020, their share decreased to 10% and 1% of all attracted deposits, respectively.

8. To comprehensively reflect and determine the demand for bank loans from businesses and households and the supply of credit resources by commercial banks, the authors have developed and offered a simplified model using the methods of system dynamics.

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БАНКІВСЬКЕ КРЕДИТУВАННЯ В УКРАЇНІ ТА ЙОГО МОДЕЛЮВАННЯ МЕТОДАМИ СИСТЕМНОЇ ДИНАМІКИ

Визначено тенденції банківського кредитування підприємств та домогосподарств в Україні та змодельовано кредитні взаємозв'язки між суб'єктами економіки за допомогою методів системної динаміки. Відображено, що на кінець 2020 р. основними тенденціями в українському банківському секторі були: 1) збільшення динаміки рентабельності капіталу, стабільно високі ставки за кредитами-депозитам до 2019 р. та їх спадна динаміка в 2020 р.; 2) спадні тренди динаміки показників частки кредитів у активах комерційних банків та показника фінансової глибини кредитування української економіки; 3) переважання частки кредитів суб'єктів господарювання відносно кредитів домогосподарств у кредитному банківському портфелі; 4) швидші темпи зростання банківських кредитів

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домогосподарствам порівняно з темпами зростання кредитування суб'єктів господарювання; 5) у галузевому контексті найбільшу частку у кредитуванні бізнес-одиниць займає сфера торгівлі, а у кредитуванні домашніх господарств – споживче кредитування; 6) половину кредитного портфеля комерційних банків становлять короткострокові позики строком до одного року; 7) залишається високою частка непрацюючих кредитів у кредитному портфелі; 8) поступове скорочення недепозитних джерел серед зобов'язань комерційних банків їх перехід на майже повне фінансування за рахунок депозитних коштів клієнтів; 9) зростання частки короткострокового і скорочення частки довгострокового депозитного фінансування комерційних банків.

На основі методів системної динаміки авторами побудована модель, що дає змогу простежити взаємозв'язки між комерційними банками та юридичними і фізичними особами, а також розраховувати прогнозні обсяги банківських кредитів відповідно до попиту на кредити з боку суб'єктів господарювання і домогосподарства (зваженого на максимальну величину кредитного навантаження) та пропозиції кредитних ресурсів комерційними банками.

З практичної точки зору характеристика тенденцій у банківському кредитуванні, моделювання взаємодії основних його учасників і визначення обсягів банківських кредитів з використанням методів системної динаміки допомагає виявити основні фактори, що впливають на попит та пропозицію банківських кредитних ресурсів на сучасному етапі розвитку України, та спрогнозувати майбутню динаміку кредитування.

***Ключові слова:** комерційні банки, банківські кредити, банківські депозити, кредитування бізнесу, кредитування домогосподарств, тенденції розвитку банківського сектора, моделі та методи системної динаміки*