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The loan-to-value ratio as a macroprudential tool and assessment of real estate in the post-crisis period

Abstract. For more than a decade, banking systems of many countries around the world have been trying to recover from the effects of the global financial crisis. The dynamics of one of the most important indicators of the effective operation of the banking sector - the level of fulfilment of loan obligations by the debtor - is analysed in the present paper. A nonperforming loan ratio (NPL) more than doubled in the EU in the period from 2008 until 2012, and the value of this indicator increased more than 20 times in the period from 2008 until 2017 in Ukraine.

Many countries worldwide have focused on activities that aim at minimizing the risks associated with lending. The experience of more than 4,000 banks in 46 countries shows that one of the most effective macroprudential tools used by European central banks for mortgage loans is the loan-to-value ratio (LTV). According to research, central banks have recommended lowering the level of LTV. Thus, in Poland, the loan-to-value ratio used to be 100% and even higher, but from 2017 the maximum level should not exceed 80%. In China, the LTV level has dropped to 40% for the secondary real estate market. In Germany, the maximum loan-to-value ratio is 80%, and mortgages with LTV of less than 60% are financed at more favourable conditions by banks. Using macroprudential policy has made it possible to stabilize the situation in the banking system, therefore in 2020 the average level of non-performing loans in the EU decreased to 2.8%. In Poland, the level of NPL is slightly higher and is 6.2%, however in Ukraine the figure remains high and reaches 41%.

This study aims to identify the dependence between the adequacy of fulfilment of the collateral and the debtor's loan obligations, which is extremely important in order to stabilize and increase the liquidity and profitability of banking institutions. The obtained results are based on the assessment of 200 loan cases for which the execution time has come.

Keywords: Loan-to-Value (LTV); Nonperforming Loan (NPL); Macroprudential Instruments; Creditworthiness; Enterprise; Assessment of Real Estate; Mortgage; Lending; Liquidity; Profitability
JEL Classification: G21; G32; R30

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**Процентне співвідношення основної суми кредиту та ринкової вартості застави
як макропруденційний інструмент й оцінка нерухомості в післякризовий період**

Анотація
Уже більше десяти років банківські системи багатьох країн світу намагаються оговтатися від впливу світової фінансової кризи. У цій статті проаналізовано динаміку одного з найважливіших індикаторів ефективного функціонування банківського сектора – рівня виконання кредитних зобов'язань боржником. З 2008 по 2012 рік у країнах-членах ЄС частка непрацюючих кредитів (NPL) зросла більше ніж удвічі. В Україні за період з 2008 по 2017 рік значення цього показника зросло більше ніж в 20 разів. Багато країн світу зосередилися на діяльності, яка була спрямована на мінімізацію ризиків, пов'язаних із кредитуванням. Досвід більше ніж 4000 банків 46 країн світу доводить, що одним із ефективних макропруденційних інструментів, який використовувався центральними банками Європи, є співвідношення основної суми кредиту та ринкової або оціночної вартості застави (LTV). За результатами проведених досліджень центральні банки рекомендували знизити рівень співвідношення основної суми кредиту та ринкової або оціночної вартості застави. Так, у Польщі показник співвідношення кредиту до вартості застави становив 100% і навіть вище, проте від 2017 року максимальний рівень співвідношення основної суми кредиту й ринкової або оціночної вартості застави може становити 80%; у Китаї рівень такого співвідношення понизився до 40% для вторинного ринку нерухомості. У Німеччині максимальне співвідношення кредиту до вартості застави становить 80%, а іпотека з рівнем співвідношення основної суми кредиту та ринкової або оціночної вартості застави менше 60%фінансуються банками на кращих умовах.
Застосування системи макропруденційних заходів дало можливість стабілізувати ситуацію в банківській системі. У 2020 році середній рівень неповернення кредитів у країнах ЄС зменшився до 2,8%. У Польщі частка непрацюючих кредитів є на дещо вищому рівні й становить 6,2%, проте в Україні цей показник і надалі залишається на високому рівні й сягає 41%.
Проведене дослідження спрямоване на виявлення залежності між достатністю забезпечення іпотечного кредиту та виконанням боржником своїх кредитних зобов'язань, що є надзвичайно важливим для стабілізації та підвищення ліквідності й прибутковості банківських установ. Отримані результати ґрунтуються на оцінці 200 кредитних справ, час виконання за якими настав.
Ключові слова: співвідношення основної суми кредиту та ринкової або оціночної вартості застави (LTV); непрацюючий кредит (NPL); макропруденційні інструменти; кредитоспроможність підприємства; оцінка нерухомого майна; іпотека; кредитування; ліквідність; рентабельність.

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**Процентное соотношение основной суммы кредита и рыночной стоимости залога
как макропруденциальный инструмент и оценка недвижимости в посткризисный период**

Аннотация
Уже более десяти лет банковские системы многих стран мира пытаются оправиться от воздействия мирового финансового кризиса. В данной статье проанализирована динамика одного из важнейших индикаторов эффективного функционирования банковского сектора – уровня выполнения кредитных обязательств должником. С 2008 по 2012 годы в странах-членах ЕС доля просроченных кредитов (NPL) выросла более чем в два раза, а в Украине за период с 2008 по 2017 годы – более чем в 20 раз.
Многие страны мира сосредоточились на деятельности, направленной на минимизацию рисков, связанных с кредитованием. Опыт более чем 4000 банков 46 стран мира показывает, что одним из эффективных макропруденциальных инструментов, который использовался центральными банками Европы, является соотношение суммы кредита к рыночной или оценочной стоимости залога. По результатам проведенных исследований центральные банки рекомендовали снизить уровень соотношения суммы кредита и рыночной или оценочной стоимости залога. В Польше показатель соотношения кредита к стоимости залога составлял 100% и даже выше, однако с 2017 года максимальный уровень такого соотношения может составлять не более 80%; в Китае уровень соотношение суммы кредита и рыночной или оценочной стоимости залога снизился до 40% для вторичного рынка недвижимости. В Германии максимальное соотношение кредита к стоимости залога составляет 80%, а ипотека с уровнем соотношения суммы кредита и рыночной или оценочной стоимости залога менее 60% финансируются банками на лучших условиях.
Применение системы макропруденциальных мероприятий позволило стабилизировать ситуацию в банковской системе. Так, в 2020 году средний уровень невозврата кредитов в странах ЕС снизился до 2,8%. В Польше доля неработающих кредитов находится на несколько высшем уровне и составляет 6,2%, однако в Украине этот показатель продолжает оставаться на высоком уровне и достигает 41%.

Проведенное исследование направлено на выявление зависимости между достаточностью обеспечения ипотечного кредита и исполнением должником своих кредитных обязательств, что является чрезвычайно важным для стабилизации, а также повышения ликвидности и доходности банковских учреждений. Полученные нами результаты базировались на оценке 200 кредитных дел, время выполнения обязательств по которым наступило.

Ключевые слова: соотношение суммы кредита и рыночной или оценочной стоимости залога (LTV); неработающий кредит (NPL); макропруденциальные инструменты; кредитоспособность предприятия; оценка недвижимого имущества; ипотека; кредитование; ликвидность; рентабельность.

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Stosunek kwoty kredytu do wartości jako narzędzie makroostrożnościowe oraz wycena nieruchomości w okresie pokryzysowym

Streszczenie
Od ponad dekady systemy bankowe wielu krajów na całym świecie próbują wyjść ze skutków globalnego kryzysu finansowego. W opracowaniu analizowana jest dynamika jednego z najważniejszych wskaźników efektywnego funkcjonowania sektora bankowego, tj. poziomu wywiązywania się dłużnika z zobowiązań kredytowych. W latach 2008-2012 w UE wielkość pożyczek niespłaconych (NPL) wzrosła ponad dwukrotnie, natomiast na Ukrainie w okresie 2008-2017 poziom tego wskaźnika zwiększył się 20-krotnie. Dużo krajów na całym świecie skupiło się na działaniach, które miały na celu zminimalizowanie ryzyka związanego z kredytowaniem. Doświadczenia ponad 4000 banków w 46 krajach dowodzą, że jednym ze skutecznych instrumentów makroostrożnościowych, stosowanych przez banki centralne Europy jest stosunek kwoty kredytu do wartości (LTV). Z badań wynika, że banki centralne zalecały obniżenie poziomu LTV. Tym samym w Polsce relacja kredytu do zabezpieczenia wyniosła najpierw 100%, a nawet więcej, ale od 2017 roku maksymalny poziom LTV mógł wynosić 80%, natomiast w Chinach w przypadku wtórnego rynku nieruchomości poziom LTV spadł do 40%. W Niemczech maksymalny wskaźnik kredytu do zabezpieczenia wynosi 80%, a kredyty hipoteczne o LTV poniżej 60% są finansowane przez banki na lepszych warunkach. Zastosowanie systemu działań makroostrożnościowych pozwoliło na ustabilizowanie sytuacji w systemie bankowym, dlatego w 2020 roku średni poziom niespłacalności kredytów w UE spadł do 2,8%, w Polsce poziom NPL jest nieco wyższy i wynosi 6,2%, natomiast na Ukrainie wskaźnik ten pozostaje wysoki, gdyż dochodzi do 41%.
Badania mają na celu określenie zależności między adekwatnością kredytu hipotecznego a wywiązywaniem się dłużnika z zobowiązań kredytowych, co jest niezwykle istotne dla stabilizacji i zwiększania płynności i rentowności instytucji bankowych. Wyniki uzyskano na podstawie oceny 200 spraw kredytowych, w przypadku których zaciągnięty kredyt został już spłacony.

Słowa kluczowe: stosunek kwoty kredytu do wartości (LTV); pożyczka niespłacana (NPL); instrumenty makroostrożnościowe; zdolność kredytowa; wycena nieruchomości; hipoteka; pożyczanie; płynność; rentowność.

1. Introduction

This is the third article in a series of articles devoted to credit scoring of enterprises - potential borrowers of mortgage. As noted in previous studies, the credit scoring of enterprises involves four components, namely: the credit record, the financial condition of the debtor, the collateral (real estate), as well as a business plan. In this part of our research we will reveal aspects related to the collateral mortgage.

Over the last 20 years, the situation on the real estate markets has changed, and this applies to various countries around the world, including the EU, Ukraine and the United States.

The global financial crisis that began in 2007, the price collapse on the real estate market in many countries, the loss of financial liquidity by banks (at least for a while), exchange rate volatility, and an increase in outstanding/overdue loans created an urgent need for this research.

The following research algorithm is proposed to reach the aim:
1. Analysis of the situation related to the collateral mortgages, in particular the price dynamics on the real estate, as well as indicators that characterize the adequacy of collateral.
2. Description of the mathematical model of the credit scoring of the potential borrower in terms of collateral mortgage, which will allow us to conduct our research.
3. Estimation of the situation related to collateral mortgages on the basis of information obtained from 200 loan cases, the repayment period for which has come.

4. Quantitative measure identification of the correlation between the level of collateral and the level of fulfilment of the loan obligations by the borrowing enterprise in the condition of the banking sector crisis.

5. Comparison of the estimation results of the collateral mortgages conducted in 2009 with the use of the enterprises credit scoring model along with the results of such assessment conducted now.

6. Substantiation of the research results in view of the situation which is typical for the banking system in Ukraine, considering the world practice related to determining the adequacy of collaterals. Based on this, the development of proposals for changes to the credit scoring model of enterprises (if necessary), which will increase the accuracy of such assessment.

2. Brief Literature Review

«When the music stops in terms of liquidity, things will get complicated. But as long as the music is playing, you've got to get up and dance. We're still dancing». Such words sounded from Chuck Prince when he summarized the rapidly accelerating housing prices (Nakamoto & Wighton, 2007).

The global financial crisis, which began in 2007, introduced many changes to the rules that for many years had been fundamental in the functioning of the global financial system, including the banking system. According to the research, one of the areas of the credit risk reduction is to standardize requirements and mathematical modelling of creditworthiness of the potential borrowing enterprise (Kruchok, 2009).

According to the experts of the National Bank of Poland, creditworthiness is not only a necessary condition for obtaining a loan, but also the main factor determining the amount, price and the required forms of collateral, thus affecting the terms of the loan agreement. The greater the creditworthiness is, the higher the bank can grant (National Bank of Poland, 2015).

There are many different approaches to credit scoring of a potential borrower. Research of many scientists stated that credit scoring is a statistical method used to predict the probability that a loan applicant or existing borrower will default or become delinquent (Loretta, 1997; Wasilewska et al., 2018). One of the common methods used by Polish banks is credit scoring. The score is the sum of all points obtained by the client as a result of the credit scoring method. The evaluation result consists of all points obtained by the client, awarded for each element of his profile. An example of such an element may be the greatest delay in the repayment of loans owned by the customer (Credit Information Bureau, 2015, p. 33).

Recent advances in Machine Learning, and more broadly in Artificial Intelligence (Bach et al., 2019), have enabled the emergence, in the last few years, of alternative methods for qualifying and quantifying the creditworthiness, using non-financial information innovative approaches, such as phone log analysis (Shema, 2019; Agarwal et al., 2018) or social network analysis.

During the global financial crisis of 2007-2009, most countries around the world conducted research aimed at minimizing the risks associated with lending. Many of the macroprudential instruments proved to be effective in mitigating systemic risk (Lim et al., 2011; Kelber & Monnet, 2014; McCann et al., 2019). Numerous measures have been developed aimed at avoiding «the risk of widespread disruption to the provision of financial services that is caused by an impairment of all or parts of the financial system, and which can cause serious negative consequences for the real economy». This is exactly the definition given to macro-prudential policy by the International Monetary Fund (IMF)/the Financial Stability Board (FSB)/the Bank for International Settlements (BIS) in 2016. Although it is worth noting that some of the measures which we call now macroprudential instruments were used by Europe's central banks in the post-war period and were mostly aimed at demand management (IMF, 2016).

Speaking of mortgage loans, an important instrument by which banks can insure themselves is LTV - an indicator that shows a relationship between loan obligations and the collateral value (Schindler et al., 2012). In order to improve the situation and increase the stability of the financial system, reduction of the LTV value was used. Wong et al. (2011) have also found LTV policies to reduce mortgage delinquency ratios and to have a positive impact on reducing cyclical systemic risk after examining these policies in 13 countries. Most countries around the world have used LTV as an effective macroprudential instrument in reducing the procyclicality of credit growth by reducing its value. Lim et al. (2011) have identified LTV and debt-to-income limits (DTI) using aggregate country-level data from 49 countries over 10 years. This research stated that in 2010, Poland

adopted measures including tighter LTV (e. g., based on loan maturity) and debt service to income ratios (Lim et al., 2011, p. 35).

In the Czech Republic, the Central Bank recommended commercial banks to comply with the DTI ratio (debt-to-net annual income) not exceeding 9, while the value of the DSTI ratio (debt service-to-net monthly income) should not exceed 45% (IMF, 2018)., In 2008, the government in the United Kingdom planned to implement measures aimed at rescuing the banking system, worth GBP 500 billion[1] (Hall, 2009). According to the Executive Order on Good Business Practice for Financial Undertakings[2], in Denmark, new borrowers from DTIs above 4 and LTV above 60% must have a fixing interest rate for at least five years. It is possible to defer depreciation provided that the interest rate is fixed for a period of 30 years.

In 2018, the National Bank of Slovakia tightened restrictions and amended existing macroprudential measures[3]. Restrictions on LTV have been tightened in the Slovak Republic, where the maximum level should not exceed 90%, no new loans with LTV exceeding 90%, the share of loans with LTV > 80% decreased to 30% by the end of 2018 and to 20% by the end of 2019.

In 2010, the LTV in China was lowered to 70% for primary homes and to 50% for second homes. By the end of the year, the LTV for second homes was lowered to 40%. Morgan et al. (2019) show the effectiveness of LTV caps on constraining mortgage credit after analyzing 4,000 banks from 46 countries. Such restrictions were quite effective and well-founded. Hence, in 2006, the real estate values in the United States reached their zenith, however 36 months later real estate values had depreciated by one third.

However, despite numerous studies on loan risk minimization, a number of issues need to be solved. An extremely important issue is to identify the impact between the collaterals and the repayment level of such loans.

It is in our article that we explored the relationship between the financial obligations fulfilment and the adequacy of collateral.

3. Purpose
The purpose of the study is to establish a relationship between the adequacy of collateral and the level of fulfilment of credit obligations by the borrower to the bank. An additional task is to verify the model of credit scoring of the enterprise developed in 2009 in terms of objectivity of assessing the adequacy of collateral in a crisis.

4. Methods
A mathematical model of the credit scoring of a potential mortgage borrower was used in the research. The essence of the model is to standardize and formalize the estimate individual components of the creditworthiness of the mortgage borrower. In addition to quantifying assessment of the potential creditworthiness of the borrower on a 100-point scale, this model allows us to identify the impact of such an assessment on the expected level of loan repayment and loan rate and compare it with the actual level of borrowers' fulfilment of loan obligations (Kruchok, 2010).

However, this article provided coverage for only that part of the model that reveals the nature of the requirements for the adequacy of collateral. First of all, the model provides a preliminary classification of mortgage and real estate objects (Table 1).

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[1] The package comprised: an increase (from GBP 100 billion to GBP 200 billion) in the amount of bank funding available under the «Special Liquidity Scheme» of the Bank of England; a recapitalisation of the UK deposit-taking sector using GBP 25 billion (later increased to GBP 37 billion) of taxpayers' money in return for which banks had to restrict dividend payouts and executive compensation and commit to lending to small businesses and homeowners; and, in return for the payment of a commercial fee, a public guarantee of up to GBP 250 billion of banks' new short- and medium-term debt issuance.

[2] This Executive Order contains provisions implementing parts of Council Directive 92/49/EEC of 18 June 1992 on the coordination of laws, regulations and administrative provisions relating to direct insurance other than life assurance and amending Directives 73/239/EEC and 88/357/EEC, (Official Journal 3 L 228, page 1) (Third Non-Life Insurance Directive) and parts of Directive 2005/29/EC of the European Parliament and of the Council of 11 May 2005 concerning unfair business-to-customer commercial practices in the internal market and amending Council Directive 84/450/EEC, Directives 97/7/EC, 98/27/EC and 2002/65/EC of the European Parliament and of the Council and Regulation (EC) No. 2006/2004 of the European Parliament and of the Council.

[3] DECREE of Národná banka Slovenska (National Bank of Slovakia) of 29 May 2018 amending Decree No. 10/2016 of Národná banka Slovenska laying down detailed provisions on the assessment of borrowers' ability to repay housing loans: https://www.nbs.sk/_img/Documents/_Legislativa/_FullWordingsOther/EN_O_7_2018.pdf

The adequacy of collateral is determined for each of the 8 classes of real estate objects (from 11 to 24) by the following factors: x_1 - LTV; x_2 - the loan term, years; x_3 - the ratio of the efficient existence of the subject to mortgage to the term of complete fulfilment of loan obligations (for the completed object; codes 13 and 23). The assessment of the collateral, along with relevant formulas, is presented in Table 2.

The following restrictions are set for the abovementioned factors (Table 3). These restrictions make it possible to formalize the assessment of the adequacy of the collateral.

In the next part of our study, with the help of the proposed model, we will examine the adequacy of collateral on the basis of information obtained from 200 loan cases, the repayment period of which has come.

5. Results

In 2008, the EU member-states felt the effects of the mortgage crisis which began in 2007 in the USA. The financial systems, as well as the banking sector of many countries around the world, needed support. Some of the banking systems lost their liquidity. Many scientists conducted research related to strengthening the soundness and resilience of the banking sector. In his research on the effectiveness of the functioning of banks in Poland, Misztal (2017) determined the factors influencing their profitability. One of the important indicators of the state of the banking system is the level of non-performing loans. In 2008, the average NPL ratio for European banks

Table 1:
Classification of collateral

Types of Collateral (Consumer Loan)	Code	Types of Collateral (Entrepreneurial Loan)	Code
Land plot	11	Land plot	21
Uncompleted construction	12	Uncompleted construction	22
Building (completed object)	13	Building (completed object)	23
Integral property complex	14	Integral property complex	24

Source: Compiled by the author based on Kruchok (2010)

Table 2:
Assessment of collateral by different factors

#	Operation	Formulas
1	The overall assessment of the collateral, *ESTC*	*ESTC = EST LTV + ESTTL + ESTUL* ≥ 0, where: EST_{LTV} - estimate by the LTV, points; EST_{TL} - estimate by the term loan, points; *ESTUL* - estimate by the ratio of the useful life of the real estate object to the term of complete fulfilment of loan obligations.
2	Estimate by the LTV for codes 11, 23, 24 (LTV $\leq$ 60%)	$EST_{LTV}^{60} = 0 < 391 - 5.66661\, x_1 \leq 85$
3	Estimate by the LTV for codes 12, 21 (LTV $\leq$ 50%)	$EST_{LTV}^{50} = 0 < 391 - 6.8\, x_1 \leq 85$
4	Estimate by the LTV for codes 13, 14 (LTV $\leq$ 70%):	$EST_{LTV}^{70} = 0 < 391 - 4.85714\, x_1 \leq 85$
5	Estimate by the LTV for codes 22 (LTV $\leq$ 40%)	$EST_{LTV}^{40} = 0 < 391 - 8.5\, x_1 \leq 85$
6	Estimate by the term loan for codes 11, 12, 13, 14 ($x_2 \leq$ 30)	$EST_{TK}^{30} = 0 < 12 - 02\, x_2 \leq 10$
7	Estimate by the term loan for codes 21, 22, 23, 24 ($x_2 \leq$ 20)	$EST_{TK}^{20} = 0 < 12 - 0.3\, x_2 \leq 10$
8	Estimate by the ratio of the useful life of the real estate object to the term of complete fulfilment of loan obligations for codes 13, 23	$EST_{BT} = 0 < 8\, x_3 - 7 \leq 5$
9	Estimate by the ratio of the useful life of the real estate object to the term of complete fulfilment of loan obligations for other codes	$EST_{BT} = 5$

Source: Compiled by the author based on Kruchok (2010)

Table 3:
Limitations of the factor scores

Loan and collateral code / Limitations for different types of collateral
11/$x_1 \leq$ 60; $x_2 \leq$ 30
12/$x_1 \leq$ 50; $x_2 \leq$ 30
13/$x_1 \leq$ 70; $x_2 \leq$ 30; $x_3 \geq$ 1,25
14/$x_1 \leq$ 70; $x_2 \leq$ 30
21/$x_1 \leq$ 50; $x_2 \leq$ 20
22/$x_1 \leq$ 40; $x_2 \leq$ 20
23/$x_1 \leq$ 60; $x_2 \leq$ 20; $x_3 \geq$ 1,25
24/$x_1 \leq$ 60; $x_2 \leq$ 20

Source: Compiled by the author based on Kruchok (2010)

was less than 3% according to the World Bank (Fourth Progress Report, Brussels, 2019). However, in 2012, the index increased to more than double and reached more than 7%, which indicated a significant deterioration in the banking system. The NPL ratio was significantly above the average level and reached even more than 45% in some countries of the European Union (Figure 1). A similar trend was characteristic of Polish banks. The situation in the banking system in Ukraine was much worse, because the NPL ratio in 2017 was as high as possible and reached 58% (National Bank of Ukraine, 2020), which was the highest index among European countries (Figure 2). In 2020, the nonperforming loans ratio in Ukraine decreased by 41%.
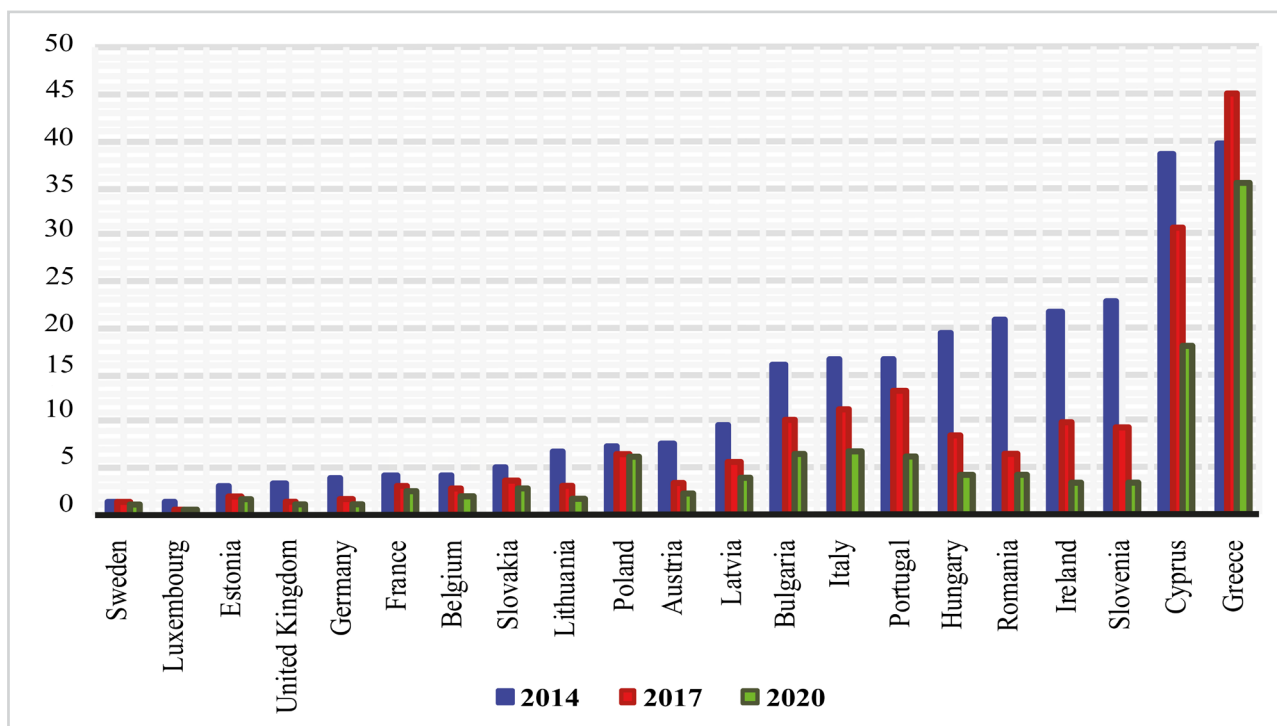

Figure 1:
Gross non-performing loans, EU's and foreign entities, % of gross loans (Euro area)
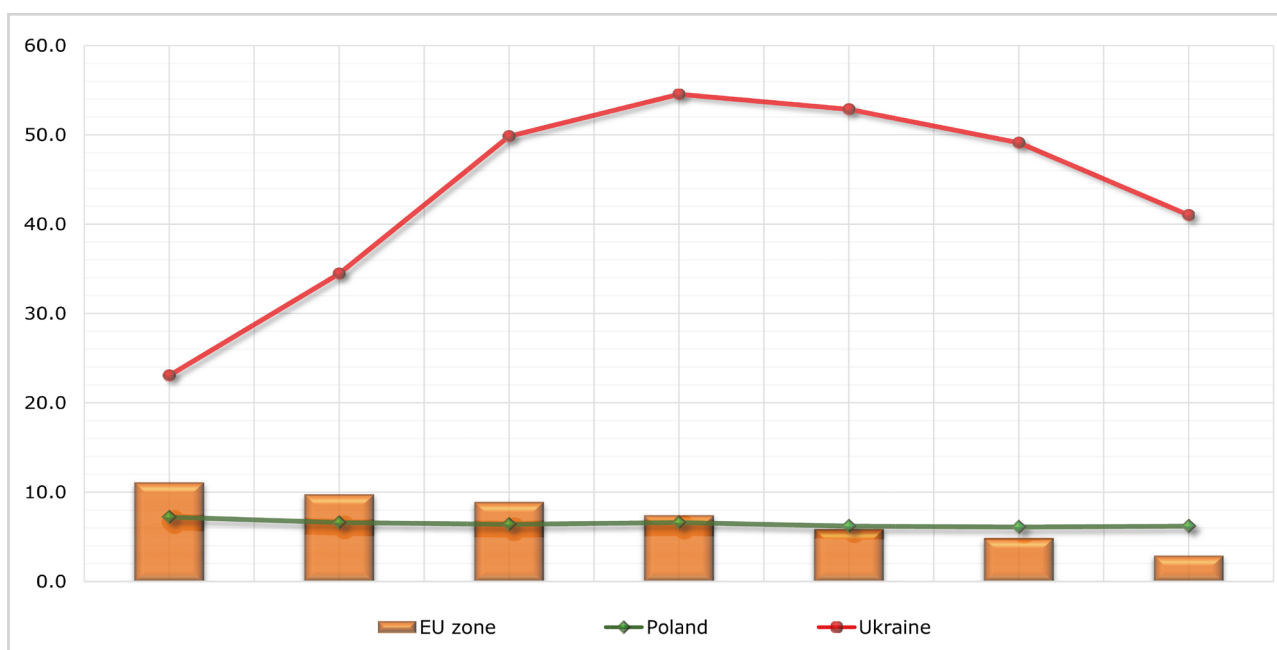Source: Compiled by the author based on Eurostat (2020)

Figure 2:
Gross non-performing loans, EU's and foreign entities, % of gross loans (Euro area and Ukraine)
Source: Compiled by the author based on data by Eurostat (2020), the European Commission (2020) and the National Bank of Ukraine (2020)

As of Q2 2020, gross NPLs and advances of percentage of total gross loans and advances in EU countries amounted 2.9% (European Banking Authority, 2020). Despite some overall encouraging progress, NPLs continues to risk the viability of the most traumatized banks and negatively affect economic growth and financial stability in some EU Member States. In 2019, the total volume of NPLs of European banks (the EU member-states) amounted to EUR 786 billion (European Central Bank, 2019), compared to EUR 588 billion in Q2 in 2020 (European Commission, 2020).

In Ukraine, as of June 2020, the NPLs index remained extremely high - UAH 561.6 billion, or EUR 18.8 billion, or almost 50% of the total amount of loans (Figure 3 and Figure 4) despite a slight decrease in the value of NPLs over the previous 2 years.
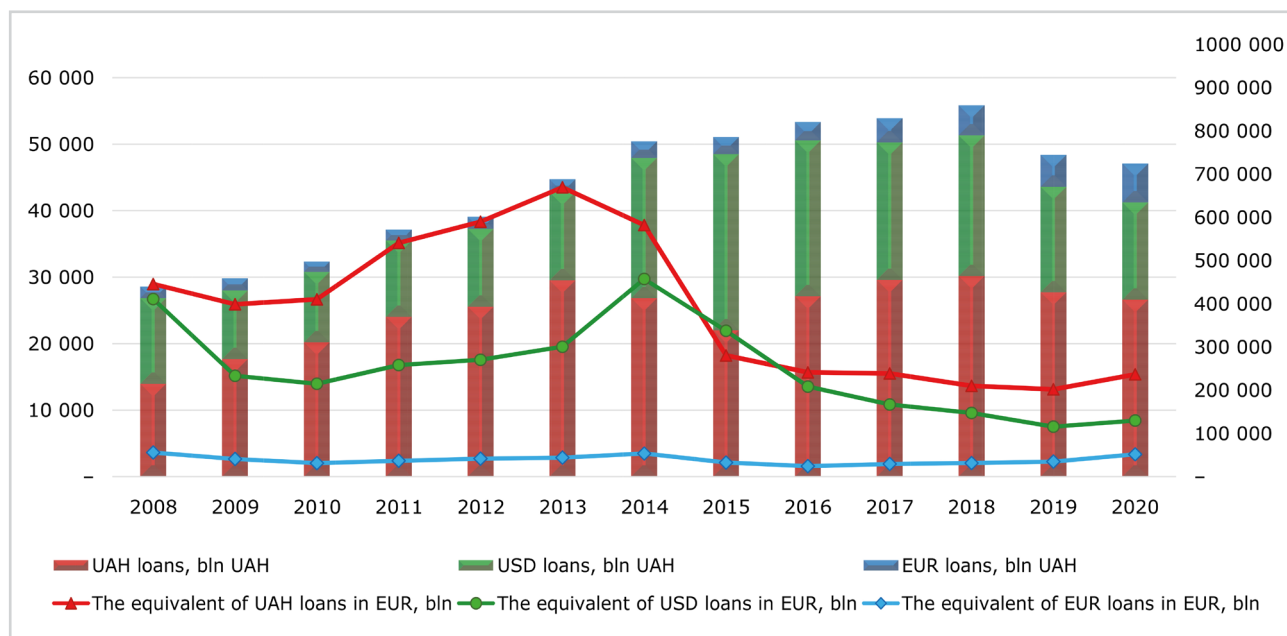

Figure 3:
Gross loans by different types of currencies
Source: Compiled by the author based on data by the National Bank of Ukraine
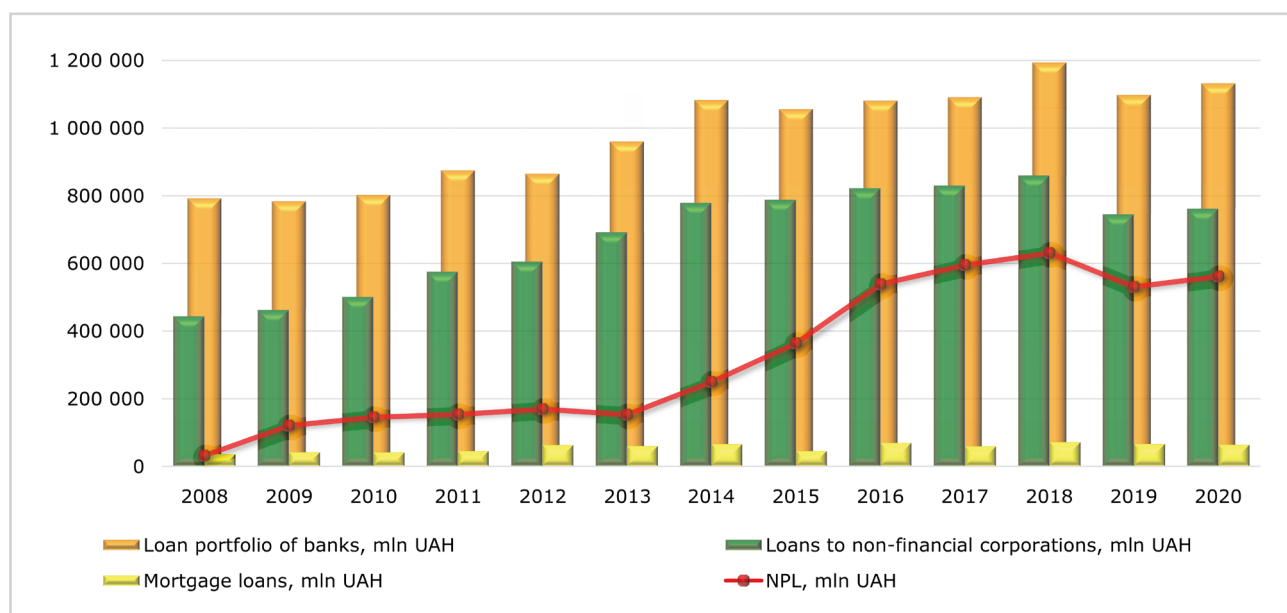and the Ministry of Finance of Ukraine (2020)

Figure 4:
Gross loans by different types and non-performing loans
Source: Compiled by the author based on data by the National Bank of Ukraine
and Ministry of Finance of Ukraine (2020)

The National Bank of Ukraine attributes such a high level of NPLs to gaps in legislation that insufficiently protect creditors' rights (there are problems with foreclosure on mortgage objects), as well as low credit requirements of the potential borrowers during the pre-crisis period. Another important problem that has led to such a high level of NPL ratio is the lending to shareholders who rushed to service loans during the crisis.

Considering that the collateral is real estate, it is worth analysing the situation in real estate markets by country because the liquidity of collateral and the stability of real estate prices play an important role in determining the adequacy of collateral.

The last 15 years have been extremely interesting for analysing the situation related to real estate markets. The analyses of real estate markets during 2005-2020 show that the situation in the European Union is ambiguous. The countries under study could be divided into two groups. In the first group of countries, the global financial crisis has negatively affected the situation in real estate markets and from the second half of 2008 prices began to fall. This trend continued in some EU member states until 2015. In 2008, there were the highest real estate prices in the EU member states. In early 2008, prices in Ireland were 160%, compared to prices in 2015. A similar situation was in other EU member states, such as Spain and Bulgaria. The average real estate prices in the EU member states were 110%, compared to prices in 2015. However, in the second group of countries the real estate prices increased throughout the study period. For example, during the period from 2005 to 2015, the real estate prices in Sweden doubled. Since 2015, almost all countries under study have seen an increase in real estate prices (Figure 5 and Figure 6).

A similar situation occurred in the real estate market in Poland and showed a sharp rise in prices during the period from 2005 to 2008 (more than twice) and a slight recessionary tendency from 2008 to 2015 (Figure 5 and Figure 6). The real estate prices in Poland increased from 2014 to 2020 (especially such an increase can be seen from 2018), and the value of the real estate at the end of 2020 was almost 37% higher than in 2015.

Real estate prices had a different trend in Ukraine during the study period. At the beginning of the study period, there was a sharp rise in real estate prices and from 2005 to 2009 prices doubled (prices were converted into USD during the calculations). Since 2009, the real estate market in Ukraine has been negatively affected by the crisis in the Ukrainian economy and prices have begun to decline. The real estate value decreased by 2.5 times. This has led to stagnation in the real estate market. Ukraine has not been able to recover so quickly from the effects of the financial crisis. Today Ukraine is the country with one of the largest declines in real estate prices among European countries over the past 15 years.
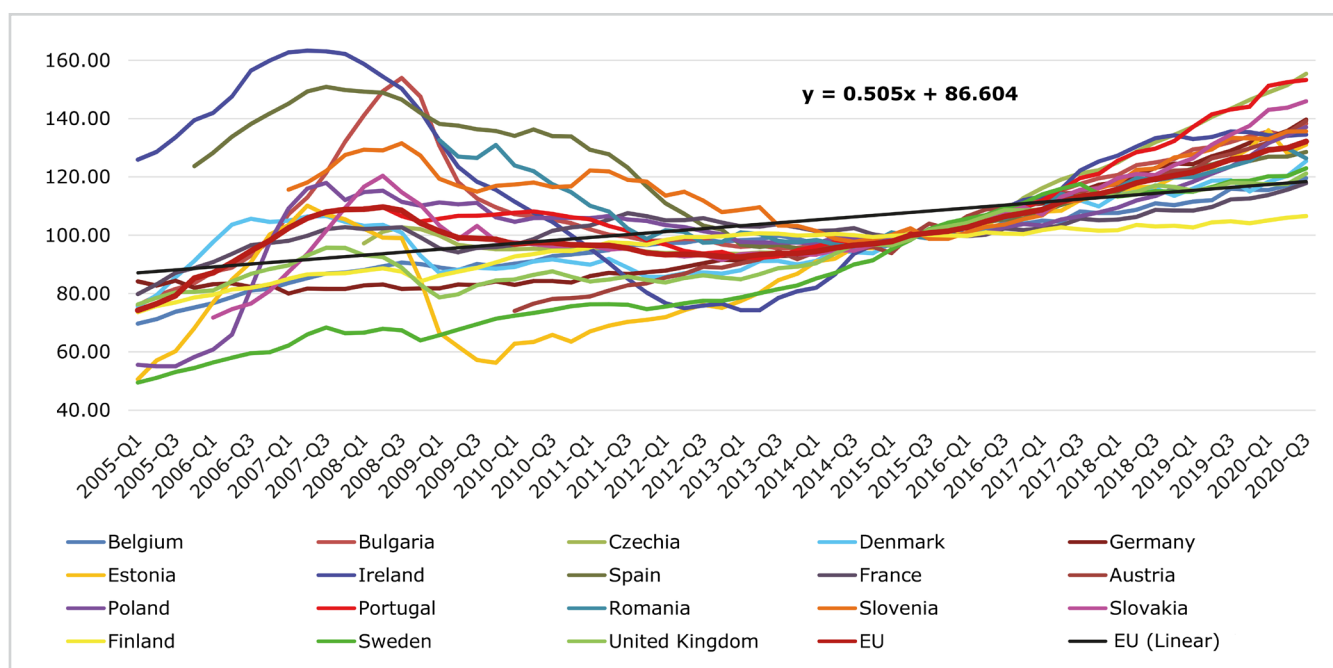

Figure 5:
House price index (2015 = 100) in EU countries, %
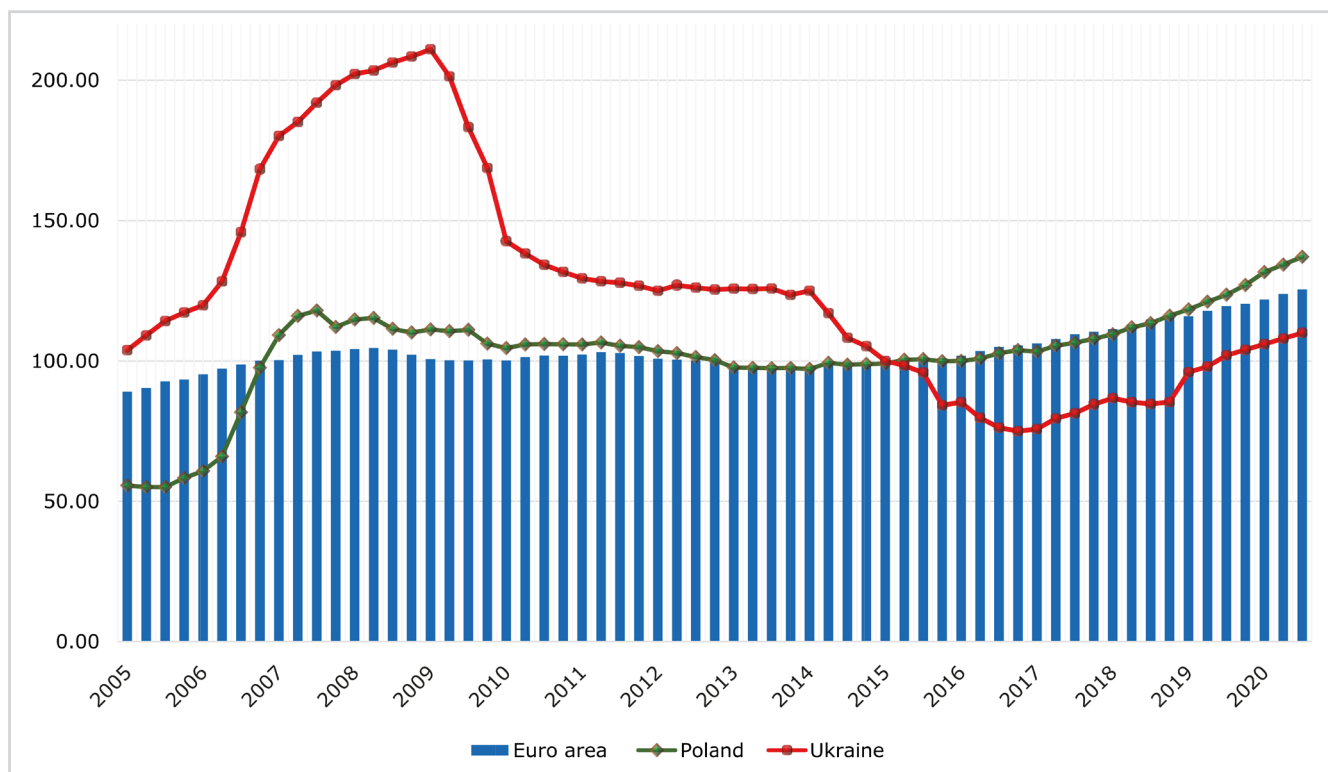Source: Compiled by the author based on Eurostat (2020)

Figure 6:
House price index (2015 = 100) in Poland and Ukraine, %
Source: Compiled by the author based on Eurostat, the Ministry of Finance of Ukraine (2020)
and Myrchyk (2017)

An analysis of the situation, which is typical for banking systems of many countries around the world, shows that it takes a lot of effort and time to rebuild them. One of the important areas aimed at improving the state of the banking sector is an objective and qualitative estimate of the credit-worthiness of a potential borrower. Increasing the requirements for potential borrowers will help to avoid increasing NPLs in the future.

With the purpose of implementation, we analysed and assessed the adequacy of collateral as one of the elements of creditworthiness of 200 corporate borrowers who applied to one of the Ukrainian banks for a loan secured by real estate. The estimate of adequacy was performed by using the model presented in the previous part of this paper.

Below we propose to consider the estimate of the adequacy of collateral on the example of two companies (the names of companies and banks have been changed due to GDPR rules) The information about the companies was obtained from credit cases. LLC «Agrosvit» has prepared a set of documents in order to obtain a loan in the bank «Inkobank». The enterprise planned to get a loan of EUR 225 thousand for a period of 28 months for the purpose of reconstruction of the dairy plant production line. The dairy plant, which was to be reconstructed within a year, was offered as a loan collateral. At the time of preparation of the loan application, the company had already financed the construction in the amount of EUR 75 thousand. Additionally, the company planned to finance the construction in the amount of EUR 132 thousand. According to experts' estimation, the market value of the dairy plant after its reconstruction would amount up to EUR 432 thousand. The remaining useful life of the building was 15 years.

 Another company LLC «SERVIS» also applied to the bank «Inkobank» with a request to provide a loan of EUR 420 thousand for 30 months for the purpose of construction of a service automobile centre of 600 m², secured by that centre, the market value of which after completion of construction would be EUR 534 thousand. The company had financed the construction of the project in the amount of EUR 54 thousand and for 30 months planned to finance the project in the amount of EUR 60 thousand. The remaining useful life of the facilities was 25 years.

According to the estimation of the adequacy of the collateral mortgage, it has been determined that the pledged real estate of LLC «Agrosvit» meets all the requirements and is sufficient, while the collateral of LLC «SERVIS» is insufficient (Table 4). The real estate of LLC «SERVIS» was

Table 4:
Results of the conducted evaluation of the collateral, LLC Agrosvit and LLC SERVIS

##	Ratio	LLC Agrosvit, points	LLC SERVIS, points
1	Estimate by the LTV, for the code 24 (0 < 85 ≥ x_1 = LTV ≤ 60%), $EST^{60}{}_{LTV}$ and for the code 22 (0 < 85 ≥ x_1 = LTV ≤ 40%), EST^{40}	391 − 5.67 x 52.19 = 95 ≤ 85 = 85	391 − 8.5 x 78.65 = − 54.69 ≤ 85 = −54.68 = 0
2	Estimate by the term loan, for the code 22 and 24 (x_2 ≤ 20), $EST^{20}{}_{TL}$	12 − 0.3 x 2.33 = 11.30 ≤ 10 = 10	12 − 0.3 x 2.5 = 11.25 ≤ 10 = 10
3	Estimate by the ratio of the useful life of real estate object to the term of complete fulfilment of the loan obligations, for the code 24 (x_3), EST_{UL}	5	5
4	The overall assessment of the collateral, $ESTOA$ ≥ 0	85 + 10 + 5 = 100	0 + 10 + 5 = 15

Source: Compiled by the authors

evaluated at the level of 15 points out of 100 possible and with such collateral the bank must refuse to provide the loan due to the lack of adequate collateral for the loan obligations.

Correlation and regression analysis was used to determine the dependence between the adequacy of the loan collateral and the level of fulfilment of the credit obligations by the enterprise. In order to conduct such an analysis, 200 credit cases, with the term of complete fulfilment of obligations, were investigated. The results of the conducted research are presented in Table 5.

After the statistical processing of the information the following system of equations was compiled:

$$11315 = 200\,a + 15952\,b,$$
$$981057 = 15952\,a + 1338553\,b.$$

As a result of solving the system, the following equation is obtained:

$$\overline{y}_x = 1.190521 * X - 38.291 \geq 0,$$

where:
$\overline{y}_x$ - the theoretical (most probable) level of fulfilment of credit obligations by borrowers depending on the assessment of loan collateral, %;
X - the overall assessment of the collateral, points.

There is a direct dependence between the loan collateral and the level of fulfilment of loan obligations by the borrowers: with an increase in the assessment of collateral by 1 point, the level of

Table 5:
Dependence between the collateral and the level of credit obligations fulfilment

No. of credit file	The overall assessment of the collateral in points, x	The most probable level of fulfilment of credit obligations by borrowers in points, y	No. of credit file	The overall assessment of the collateral in points, x	The most probable level of fulfilment of credit obligations by borrowers in points, y
1	68	60	...188	...100	...85
2	92	100	189	100	85
3	94	70	190	60	40
4	64	65	191	60	55
5	60	30	192	84	60
6	65	20	193	76	55
7	95	100	194	60	40
9	100	85	196	63	0
10	60	40	197	100	40
11	93	100	198	84	55
12	64	55	199	97	60
13...	100...	85...	200	75	45
Average value	80	56.6	Average value	80	56.6

Source: Compiled by the author based on Kruchok (2010)

credit obligations increases by almost 1.19 percentage points. The pair correlation coefficient is $r_{y/x}$ = 0.7066. Thus, the relationship between the studied variables is relatively high.

Our research has shown that even when the loan has sufficient collateral (real estate), the credit risk remains extremely high. If the loan collateral score reached 100 points, the expected level of loan obligations is only 80.76%. That is, the availability of adequate collateral does not guarantee the bank that the debtor will completely fulfil their financial obligations.

The results of the research conducted in 2009, which involved standardizing and formalizing the requirements for collateral mortgage, as well as quantifying its adequacy, were somewhat different. The system of equations, obtained as a result of the research in 2009, is presented below:

$$9600 = 100\,a + 6819\,b,$$
$$676225 = 6819\,a + 492301\,b.$$

As a result of solving the system, the following equation is obtained:

$$\overline{y}_x = 42.0706 + 0.79087\,x,$$

where:

$\overline{y}_x$ - the theoretical (most probable) level of fulfilment of credit obligations by borrowers depending on the assessment of loan collateral, %;

X - the overall assessment of the collateral, points.

Thus, an increase of collateral score by 1 point leads to an increase of the level of loan obligations fulfilment by almost 0.791 percentage points. If the loan collateral score reaches 73.24 points and above, in most cases there is a complete (100%) fulfilment of the debtor's financial obligations to the bank (Figure 7). If the score decreases to 60 points, the expected level of credit obligations falls to 89.5%. The pair correlation coefficient is $r_{y/x}$ = 0.68082 (Kruchok, 2010).

On the one hand, according to the results of the analysis of credit cases that was conducted in 2009 and 2020, the pair correlation coefficient is almost the same: ($r_{y/x}$ (2009) = 0.68082 and $r_{y/x}$ (2020) = 0.7066). Such a value of indices confirms the dependence between the adequacy of loan collateral and the fulfilment of financial obligations to the bank by the debtor. On the other hand, the 2009 research showed that with the score of the collateral at about 73 points and above the credit risk is minimized, while in 2020 with the collateral score of 100 points, there were no guarantees of the debtor's complete fulfilment of their obligations to the bank (only at approximately 80%).
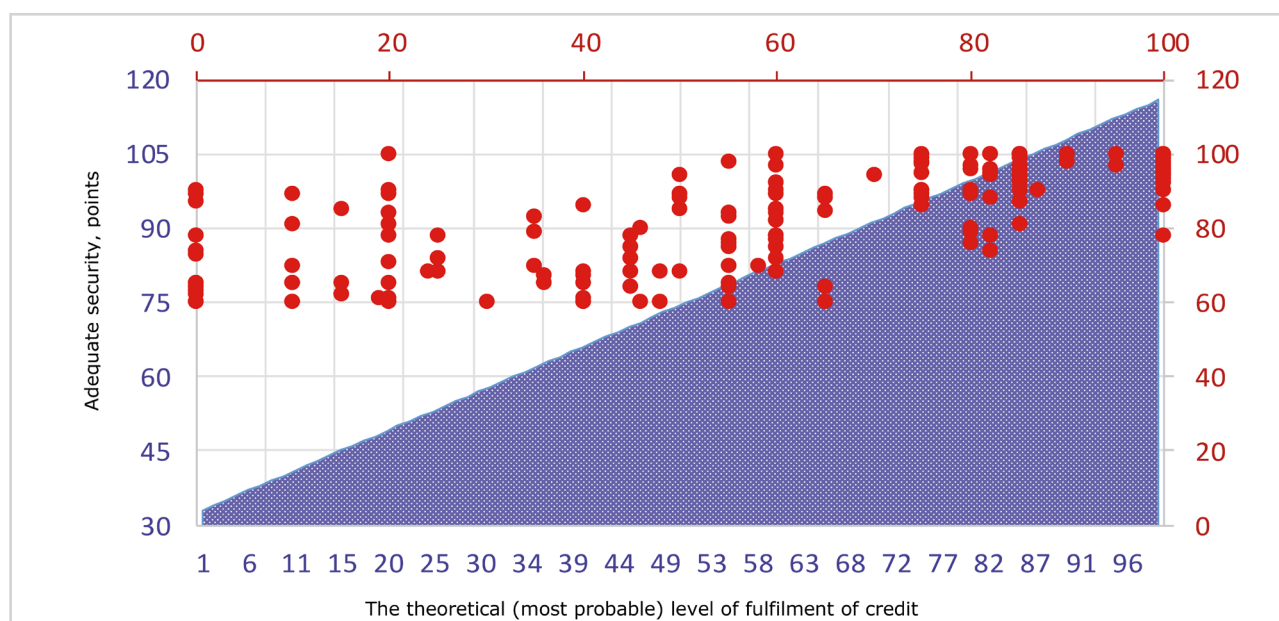

Figure 7:
The relationship between the collateral level and the level of fulfilment of credit obligations
Source: Compiled by the authors

6. Conclusions

The conducted research is related to the credit scoring of borrower-enterprises in terms of collateral, as well as identifying the dependence between the adequacy of collateral for credit obligations and fulfilment of the financial obligations by the debtor to the bank. Considering the results of the conducted research, the following facts have been determined.

1. The analysis of lending during the crisis and post-crisis period showed that banking institutions around the world needed governmental support and macro-prudential measures were introduced to minimize systemic risks in order to maintain the financial stability of credit institutions.

2. It has been established that the average level of NLP ratio in the EU in early 2008 was about 3%, however in 2012 as a result of the global financial crisis, the figure more than doubled and reached about 7%. However, in some EU countries, depending on the level of impact of the global financial crisis on the banking sector, the level of NLP ratio was extremely high. For example, in Greece, the NLP ratio increased to 45% in 2017, indicating an extremely negative state of the country's banking sector. In Ukraine, the NLP ratio increased from 4% to 58% in 2017 and to 50% at the beginning of 2020, which led to a temporary loss of liquidity of most banking institutions, as well as a significant increase in credit rates. Unfortunately, in Ukraine this level remains extremely high and, as of the end of 2020, it was about 41%. It should be noted that in 2020, as a result of macroprudential measures, the average level of NLP ratio in the EU decreased to about 2.8%.

3. The results of the study show that real estate as a mortgage object plays an important role in the process of crediting and the adequacy of such collateral reduces credit risks. The loan-to-value index is recognized as one of the effective tools of macroprudential policy. Most countries have lowered the value of LTV to improve the quality of institutions' credit assets.

4. Based on the evaluation of 200 credit cases aimed at determination of the influence of the collateral adequacy of the level of borrowers' fulfilment of their obligations to banks (using correlation-regression analysis), it was found that the pair correlation coefficient was 0.7066. This level of the pair correlation coefficient indicates that by 49.93% (the meaning of determination coefficient $R2$) the level of credit obligations depends on the adequacy of the collateral.

5. Unfortunately, even the availability of adequate collateral does not guarantee debtors' fulfilment of their loan obligations to Ukrainian banks. The analysis of the banking system, as well as the results of the research indicate a significant impact of the following factors on the level of loan repayment by the debtor to the bank: gaps in legislation on foreclosure on mortgage object, considerable expenses for banks to enforce debt through the courts, probability of crediting of interconnected persons, as well as understated requirements for the creditworthiness of a potential borrower in the pre-crisis period. The analysis makes it possible to state that the approach used to evaluate real estate as the mortgage objects provides an opportunity to objectively assess the collateral.

Further research will focus on the analysis of multiple correlations for the purpose of identification of the influence of all the components of creditworthiness (credit history, financial condition, collateral and business plan) on the level of fulfilment of the debtor's credit obligations to the bank. In addition, it is important investigate the impact of the level of fulfilment of loan obligations on the loan interest rate, through which the banking institution will be able to cover all the expenses associated with the lending process and plan the required level of profitability.

References

1. Agarwal, R. R., Lin, C. C., Chen, K. T., & Singh, V. K. (2018). Predicting financial trouble using call data - On social capital, phone logs, and financial trouble. *PLoS One*, *13*(2). https://doi.org/10.1371/journal.pone.0191863
2. Bach, M. P., Krstić, Ž., Seljan, S., & Turulja, L. (2019). Text Mining for Big Data Analysis in Financial Sector: A Literature Review. *Sustainability*, *11*(5), 1277-1304. https://doi.org/10.3390/su11051277
3. Credit Information Bureaus. (2015, October 19). *Everything you want to know about scoring*. http://www.bik.pl (in Pol.)
4. ESRB. (2018). *A Review of Macroprudential Policy in the EU in 2018*. https://www.esrb.europa.eu/pub/pdf/reports/esrb~32aae4bd95.report190430_reviewofmacroprudentialpolicy.pdf
5. EUR-Lex. (1992). Council Directive 92/49/EEC of 18 June 1992 on the coordination of laws, regulations and administrative provisions relating to direct insurance other than life assurance and amending Directives 73/239/EEC and 88/357/EEC. *Official Journal of the European Communities, L 228,* 1-23. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.1992.228.01.0001.01.ENG&toc=OJ:L:1992:228:TOC
6. European Banking Authority. (2020). *Risk Dashboard data as of Q2 2020.* https://www.eba.europa.eu/sites/default/documents/files/document_library/Risk%20Analysis%20and%20Data/Risk%20dashboard/Q2%202020/933053/EBA%20Dashboard%20-%20Q2%202020.pdf

7. European Commission. (2019). *Communication from the commission to the European Parliament, the European Council, the Council, the Council and the European Central Bank. Fourth Progress Report on the reduction of non-performing loans and further risk reduction in the Banking Union.* https://ec.europa.eu/finance/docs/policy/190612-non-performing-loans-communication_en.pdf

8. European Commission. (2020). *Communication from the commission to the European Parliament, the European Council, the Council, the Council and the European Central Bank. Tackling non-performing loans in the aftermath of the COVID-19 pandemic.* https://ec.europa.eu/finance/docs/law/201216-communication-non-performing-loans_en.pdf

9. European Union. (2005). Directive 2005/29/EC of the European Parliament and of the council of 11 May 2005 concerning unfair business-to-consumer commercial practices in the internal market and amending Council Directive 84/450/EEC, Directives 97/7/EC, 98/27/EC and 2002/65/EC of the European Parliament and of the Council and Regulation (EC) No 2006/2004 of the European Parliament and of the Council. *Official Journal of the European Union, L 149,* 22-39. https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2005:149:0022:0039:EN:PDF

10. Eurostat. (2020). *Gross non-performing loans, domestic and foreign entities - % of gross loans.* https://ec.europa.eu/eurostat/databrowser/view/TIPSBD10/default/table

11. Eurostat. (2020). *The house price index.* https://ec.europa.eu/eurostat/databrowser/product/page/TIPSHO40

12. Hall, M. (2009). Bank bailout mark II: Will it work? *Journal of Banking Regulation, 10,* 215-220. https://doi.org/10.1057/jbr.2009.5

13. Hall, M. J. B. (2010). The Sub-Prime Crisis, the Credit Crunch, and Bank «Failure»: An Assessment of the U.K. Authorities' Response. In Bliss R. R. and Kaufman G. G. (Eds.), *Financial Institutions and Markets.* New York: Palgrave Macmillan. https://doi.org/10.1057/9780230117365_4

14. IMF-FSB-BIS. (2016). *Elements of Effective Macroprudential Policies Lessons from International Experience.* https://www.imf.org/external/np/g20/pdf/2016/083116.pdf

15. International Monetary Fund. (2018). *Regional Economic Outlook Europe: Domestic Expansion Running into External Turbulence.* https://doi.org/10.5089/9781484375402.086

16. Kelber, A., & Monnet, É. (2014). Macroprudential policy and quantitative instruments: a European historical perspective. *Financial Stability Review, Banque de France, 18,* 151-160. https://ideas.repec.org/a/bfr/fisrev/20141815.html

17. Kruchok, N. (2010). *Mortgage in Ukraine: state and prospects for development.* LLC Niczlawa.

18. Kruchok, N. (2010). Standardization and formalization of requirements for the collateral. *Papers of the National Bank of Ukraine, 2,* 42-43 (in Ukr.).

19. Lim, C. H., Costa, A., Columba, F., Kongsamut, P., Otani, A., Saiyid, M., Wezel, T., & Wu, X. (2011). Macroprudential Policy: What Instruments and How to Use Them? Lessons from Country Experiences. *IMF Working Papers,* 11/238. https://www.imf.org/external/pubs/ft/wp/2011/wp11238.pdf

20. Loretta, J. M. (1997). What's the Point of Credit Scoring? *Business Review*, Sep, 3-16. https://econpapers.repec.org/article/fipfedpbr/y_3a1997_3ai_3asep_3ap_3a3-16.htm

21. McCann, F., & O'Toole, C. (2019). Cross-border Macroprudential Policy Spillovers and Bank Risk-Taking. *International Journal of Central Banking*, *15*(4), 267-311. https://www.ijcb.org/journal/ijcb19q4a8.htm

22. Ministry of Finance of Ukraine. (2020). *Official exchange rates of foreign currencies.* https://minfin.com.ua/ua/currency/nbu/eur/2020-06-01/2020-06-30 (in Ukr.)

23. Misztal, P. (2017). Efficiency of cooperative banks in Poland compared to other European Union member states. *Studia i Materiały Wydziału Zarządzania i Administracji Wyższej Szkoły Pedagogicznej im. Jana Kochanowskiego w Kielcach (Studies and Materials of the Faculty of Management and Administration of the Pedagogical University of Jan Kochanowski in Kielce), 21*(3), Vol. 2, 135-148. http://yadda.icm.edu.pl/yadda/element/bwmeta1.element.ekon-element-000171522029 (in Pol.)

24. Morgan, P., Paulo R., & Nimesh, S. (2019). LTV policy as a macroprudential tool and its effects on residential mortgage loans. *Journal of Financial Intermediation*, *37*, 89-103. https://doi.org/10.1016/j.jfi.2018.10.001

25. Myrchyk. (2017). *Changes in real estate prices over the past 10 years.* https://neruhomo.in.ua/zmina-cin-na-neruxomist-za-ostanni-10-rokiv (in Ukr.)

26. Nakamoto, M., & Wighton, D. (2007, July 10). *Bullish Citigroup Is «Still Dancing» to the Beat of the Buy-out Boom.* Financial Time. https://www.ft.com

27. National Bank of Poland (NBP). (2015). *Bank loan as a source of business financing. The project «Entrepreneurship in practice».* Rzeszów. http://www.ekonomik.rzeszow.pl/attachments/article/643/SKRYPT.pdf (in Pol.)

28. National Bank of Slovakia. (2018, May 29). *Decree of Národná banka Slovenska of 29 May 2018 amending Decree No. 10/2016 of Národná banka Slovenska laying down detailed provisions on the assessment of borrowers' ability to repay housing loans.* https://www.nbs.sk/_img/Documents/_Legislativa/_FullWordingsOther/EN_O_7_2018.pdf

29. National Bank of Ukraine. (2020). *The high non-performing loans (NPL) ratio remains a significant problem for the banking sector.* https://bank.gov.ua/en/stability/npl

30. Schindler, Y., & Laux, J. (2012). Mortgage Meltdown: Default Sensitivity To Declining Home Values And Loan-To-Value Ratios. *Journal of Applied Business Research (JABR)*, *28*(6), 1151-1158. https://doi.org/10.19030/jabr.v28i6.7331

31. Shema, A. B. (2019). Effective credit scoring using limited mobile phone data. *Proceedings of the Tenth International Conference on Information and Communication Technologies and Development, 7,* 1-11. https://doi.org/10.1145/3287098.3287116

32. Wasilewska, N., Wasilewski, M., & Zabolotnyy, S. (2018). The Enterprise's Financial Condition Assessment as a Component of its Creditworthiness. *Problems of World Agriculture, 18*(33), 493-503. https://doi.org/10.22004/ag.econ.281385

33. Wong, T., Fong, T., Li, Ka-Fai, & Choi, H. (2011, February 23). Loan-to-Value Ratio as a Macroprudential Tool. Hong Kong's Experience and Cross-Country Evidence. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1768546