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REBALANCING TOOLS FOR COMPREHENSIVE REAL ESTATE MANAGEMENT: MODELING THE DEMAND FUNCTION FOR MORTGAGE BUYERS

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Abstract:

The problem of real estate management in the growing environment of electronic and smart investment and sales tools is becoming increasingly important in matters of rebalancing the value of property and calculating the risks arising from implementing the mortgage loan agreement. This study's purpose is to investigate the prospect of using a model for planning insurance portfolios with an account of the needs of consumers to insure the contract's lifecycle in the face of rising uncertainty. The basis for the investigation was Kahneman and Tversky's perspective theory. It allowed the unveiling of the difference between the need to fulfil obligations and the need to preserve wealth. The paper modelled and tested the utility hypothesis of homeownership as well as constructed a value function model for the analysis of insurance needs. To model the function's expression and approximate the dynamics of the premium functions, the Approximation of One Variable Function tool was used. The assumption on the maximum growth in insurance premiums on equipment and furnishings for homes purchased with mortgages at 30-35% of the contract period was confirmed. It was proved that the utility of outstanding debt increases as the debt is paid.

Key words: *mortgage, insurance, household finance, home lending, lending model*

1. Introduction

Technological changes and the emergence of electronic investment tools and financial management tools are changing the structure of investments. Real estate continues to be one of the top investments in developed countries, and its financing continues to be carried out in many cases with the help of mortgage loans (Nicoletti and Zhu, 2022). A loan supplemented with savings for a down payment becomes a more conservative investment tool compared to using online lending platforms under a mortgage or owning real estate (Naoi et al., 2019). Increasingly, new tools and forms of crowdfunding and online landing are being used, raising the question of the importance of identifying and educating the optimal financial instruments for investing in real estate and ensuring their safety in the world of electronic finance (Jiang et al., 2020).

Making investments often requires processing more current information and selecting adequate risk calculation tools. Real estate transactions are complex and costly, which negatively affects the liquidity of real estate, a market that is a complex system in constant evolution (Wolniak et al., 2020).

A study of the experience of residential mortgage lending and the problems that have arisen in this area in recent years (FitzGerald, 2019) suggests that this area will undergo certain transformations due to the mortgage crisis (Kahn and Kay, 2020). The use of online trading tools and the provision of financial services online contributes to an increase in the volatility of the real estate market. This results in the development of analysis and decision-making systems in the real estate market under conditions of greater uncertainty based on AI mechanisms (Renigier-Biłozor et al., 2021). This trend has become particularly pronounced as a result of the COVID-19 pandemic, considering the risks associated with it (Francke and Korevaar, 2021), which is evident in the hotel, retail (Ling et al., 2020), and office property sectors (Agrawal et al., 2020). Given the impact of the recession on the welfare of households (Kurmann et al., 2020), it is necessary to pay attention to the development of simple and affordable methods of investment in real estate and insurance, which in the new modern conditions will help companies and managers prevent loss of rent and mortgage defaults (Kundid Novokmet and Matković, 2020). There is a situation in the market when buyers put off buying a home and sellers are hesitant to accept lower offers (Aastveit and Anundsen, 2022), the solvency of "old" borrowers and the public's demand for new loans is reduced (Bahlous-Boldi, 2020).

Rebalancing the value of property and the relevance of calculating rapidly changing risks arising during the implementation of a mortgage loan agreement make it relevant to use models that take into account the negative experience of private owners who have experienced a series of successive economic shocks and are afraid of losses. This approach is more consistent with the real situation and will improve the quality of the portfolio for property managers. It also contributes to promoting real estate sales and increasing effective demand and can positively influence the training of managers in the field of real estate and improve the policy of companies in the real market.

Most studies on the demand for insurance use one canon: the model of expected utility for a risk-averse person (Bhutta and Keys, 2022). To model the demand for insurance today it is proposed to apply the model of demand forecasting based on the

method of reference vectors using the rule of large numbers and ranking of features (Qin and Liu, 2022), the econometric approach of Box-Jenkins to build an autoregressive integrated moving average model for data with the statistics of the standard deviation (Kumar et al., 2020). Common methods are cumbersome and complex, the use of AI tools is often obscure to the understanding of the borrower and can cause prejudice and deter investment decisions (Ullah et al., 2021).

In view of the above, the study aims to explore the prospects of using the model of actuarial valuation of the demand for real estate insurance based on the approach of Kahneman and Tversky's "The Prospect Theory" (Kahneman and Tversky, 1979). As a result, it is planned to offer an original interdisciplinary actuarial theory modelling approach for sustainable insurance portfolios for further real estate management, combining quantitative and qualitative assessment of the economic and cultural phenomenon of "consumption" in the mortgage insurance market. This will enable the formulation of approaches to insurance and property management strategies, taking into account that homeowners' insurance needs change over the life cycle of the contract. Comprehensive real estate management, based on technological changes and the inclusion of electronic platforms and new electronic trading mechanisms in trading, requires new measurement and analytics tools. Involving more people in the buying process through electronic platforms and faster market changes creates the need for portfolio rebalancing.

2. Mortgage lending and mortgage insurance: theoretical issues

2.1 Mortgage lending, demand factors and trends in the housing market

Since further modelling is based on data collected from U.S. public sources, which, unfortunately, is not possible in the practice of other markets, let us dwell a little more on its features. The US has historically had a two-tiered mortgage system, and the federal government has created several programs to promote mortgage lending. The US mortgage market is the largest, most developed and complex mortgage market in the world, both in the form of organization and in the types of financial and mortgage instruments. A significant number of institutions operate on it (Brener, 2020), so this system should be visualized with a flowchart (Figure 1).

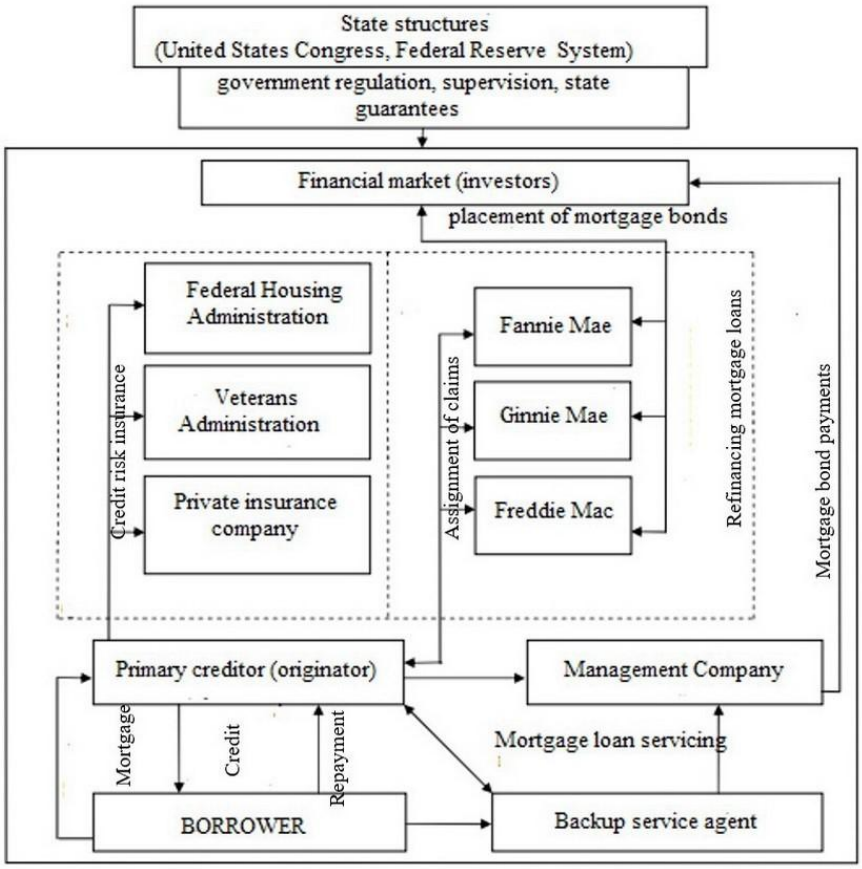

Figure 1. Organizational and functional two-tier model of financial resources formation in the United States.

Note: compiled on the basis of Brener (2020)

The model of this market is specific due to the possibility of a constant inflow of additional credit resources to the primary market from a very strong secondary market for mortgage-backed securities (Iroham et al., 2019). This same feature creates several additional risks associated with the activities of stock markets and their crises. Federal mortgage associations balance these risks and can refinance mortgage loans. Purchasing residential mortgages primarily receives funding from the proceeds of pass-through mortgage-backed securities. This class of securities is issued using SPV (Special Purpose Vehicle), which increases their reliability and guarantees high liquidity in the secondary mortgage market. SPV pushes participants to the possibility of additional insurance of their securities.

For this two-tier model, securitization is the most significant and defining element. It provides both the attraction of financial resources from institutional and private investors and provides an opportunity to reduce the cost of a mortgage for the borrower. For many researchers, this characteristic of the model is also the moment that determines its increased reliability in the face of the emergence of new electronic financial instruments and the rapid expansion of the market with the help of new financial instruments (Renigier-

Biłozor et al., 2021; Ullah et al., 2021). This effect is generated through the participation of low-cost resources attracted from free financial competitive markets. This can also help reduce financial and credit risks due to the fact that they are distributed among a significantly larger number of participants in the mortgage lending system (Loomans and Kaika, 2023).

The Federal Reserve and its monetary policy are among the most important factors; interest rates are influenced by the setting of the funds' interest rate and the adjustment of the money supply (de Haan and Mastrogiacomo, 2020). At the same time, today's consumer, living in an era of digitalization of the economy and social life, is characterized by changes in their behavior (Chang and Koss, 2019), for example, between 2010 and 2016, American technology lenders ("FinTech") increased their market share of mortgage lending from 2 to 8 per cent (Fuster et al., 2019).

When it comes to influencing mortgage demand and property management in general, mortgage borrowers seek the lowest rates, but lenders manage risk with the interest rates they charge, making the lowest interest rates available to borrowers with excellent credit histories (Agarwal et al., 2023). Interest rates, inflation risk, and development finance risk are monitored in property management (Muka and Wibowo, 2021). Gradual price increases are critical for mortgage lenders, who must maintain interest rates at levels sufficient to overcome declining purchasing power. Strong economic growth leads to higher incomes and higher consumer spending, including home mortgages. Stimulating housing demand is used for economic activity during periods of weak economic growth (Benmelech et al., 2023), as the multiplier effect in the housing market can be significant (Aastveit and Anundsen, 2022). The demand stimulus policies enacted after the financial crisis have a significant impact on sales (Fritzsche and Vandrei, 2019). Results show that housing market stimulus is more effective during periods of slowing markets (Bhutta and Ringo, 2021). It turns out that monetary policy projects aimed at increasing mortgage payments during booms and reducing them during downturns work better than fixed-rate mortgages (Guren et al., 2021).

One should not forget the unpredictable factors. The COVID-19 crisis affected the real estate sector in different ways (Ling, et al., 2020). High market uncertainty first led to a drop in supply in developed markets, including the U.S., where market sentiment for single-family homes showed a pessimistic decline of -60%, followed by a recovery of optimism (+177%) (D'Lima and Thibodeau, 2020). Developed economies began investing in real estate as early as 2020 (Balemi et al., 2021), fueling a boom in unmet demand (Kurmann et al., 2020).

2.2. Mortgage Insurance and models for assessing the level of risk and need for mortgage insurance

Most studies on risk assessment and insurance demand use the expected utility model for the risk-averse person (Bhutta and Keys, 2022), assuming that wealth grows along with sensitivity to the risk of its loss, generating an insurable interest. The demand for insurance reflects the owner's interest in preserving the object of insurance, and a decline in the welfare of society entails a decline in such demand (de Haan and

Mastrogiacomo, 2020). However, the real situation does not always correspond to this theory, since the relative demand for insurance may be higher for owners of medium or small capital. The stakeholder seeks to maintain a familiar level of welfare, and with small amounts of capital and average monthly income, such support requires additional insurance guarantees. In chronic poverty, a household cannot be a borrower because insurance payments would reduce the possibility of lifetime consumption (Kovacevic and Semmler, 2019). A "poverty trap" emerges, involving the possibility of improvement through, for example, purchased loans (Wolff, 2020), which can be secured by real estate and furniture.

Depending on which group the material good belongs to, the person associated with it assesses the risks associated with its possession and use differently. Behavioral economics studies the relationship between psychological factors and decisions (Bernheim et al., 2019). Studying the question of the value of money in terms of psychology, Bernoulli (2011) concluded that the value (utility) of money is a logarithmic function of its quantity (wealth). When the marginal value of wealth decreases, the average person will avoid risk in favor of a guaranteed amount (Bernheim et al., 2019). The proposed approach to decision-making under conditions of risk made it possible to find arguments for the economic justification of several phenomena that are difficult to interpret, for example, to explain why poor people buy insurance and why rich people sell it to poor people (Monroe et al., 2020).

According to prospect theory (Ullah et al., 2021), the need to maintain the achieved way of life under conditions of risk is higher than the need to improve it. In addition, the level of risk of small losses relative to the initial level of well-being is felt stronger than the possibility of global losses, the probability of which is estimated as very small. This phenomenon is reflected in the form of a loss probability weighting function, according to which the weight given to the probability of a small loss grows much faster up to a certain point than the weight given to a higher loss. A view of this probability weighting function is shown in Figure 2. This function explains the need for small-loss insurance.

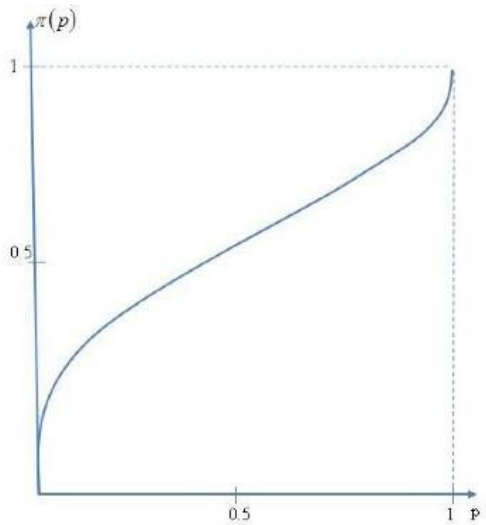

Figure 2. Weighting function of probability by Kahneman.

Thus, one can say that prospect theory explains the need for insurance by the prospect of winning or losing, rather than simply by the level of uncertainty associated with risk. Each individual can estimate for himself or herself the optimal level of risk separately for each case of loss of real estate. In addition, at a certain level of insurance premiums, individuals will first assess their level of risk and the possibilities of deviating from that prospect. The risk is that the deviation could be greater than expected and result in a loss. Concerning losses, individuals prefer risk and will insure if the loss occurs with some degree of certainty, rather than because of risk aversion itself. An interesting development of prospect theory is the stochastic model, according to which users who understand the insurance product buy more insurance the less they fear loss. In addition, higher loss aversion implies a lower acceptance rate, and demand for insurance may increase with more frequent payouts and deferred premiums (Martin et al., 2021).

To provide insurance protection against potential losses, insurance products have traditionally been offered whose totality is capable of providing a relatively comprehensive indemnity. As insurance coverage increases, so does its cost (Lampe and Würtenberger, 2018), which may seem unattractive to the insurance consumers of their monthly income. That is why the area of small but frequent damages seems to consumers to be in the most demand for insurance. However, for the insurance company such risks are of interest when they are massive, which raises the problem of identifying the carriers of risks and the level of their insurable interest. The study of the influence of probability and volume of losses concludes that the propensity to insure depends not on the number of losses but on their probability (Allen et al., 2023). Modern researchers have analyzed policyholders' attitudes to large and rare (catastrophic) risks. The analysis has revealed that the main obstacle to their insurance is the lack of relevant information (de Haan and Mastrogiacomo, 2020). Duanmu et al. (2022) point to the trend toward small-risk insurance, confirmed by real-world statistics.

Mortgage lending insurance has been studied in the academic literature for a long time. At the same time, there is some gap regarding the study of methods for assessing the ratio of benefits and risks of mortgage insurance in the context of fintech and new technologies for expanding access to the retail market for such services. The relevance of the model proposed here in comparison with other studies lies in a simpler calculation method for the end interested user, therefore facilitating its integration with online fintech tools and some additional bonuses, such as the likelihood of identifying discriminatory practices before investing. These conditions significantly change the living conditions of this market and affect the interaction of government society as well as the sustainable development of high-technology processes.

3. Materials and methods

3.1. Theoretical basis

The work plans to investigate the areas of maximum insurable interests of persons who purchase real estate with borrowed funds and repay debts by the mortgage

agreement. The use of the zone of maximum insurance interests by managers will significantly increase the real volume of real estate sales and contract insurance. Kahneman and Tversky's (1979) theory of prospects was used as the theoretical basis of the study. The classical value function is reflected as a combination of two functions: exponential, describing capital gains, and logarithmic, describing capital utility. The rate of growth of sensitivity to the risk of loss of capital gains (value) is especially high when its volume is small, and the rate of growth of sensitivity to the risk of increasing debt (value) changes rapidly when it is small.

The approach to assessing the demand for insurance in the conditions of a person concluding a mortgage agreement assumes that a purchaser is simultaneously in two situations:

- a gradual increase in paid property rights to housing, which is subject to property risks;

- gradual reduction of debt, non-payment of which can lead to the loss of previously paid property rights, which creates another group of risks associated with a lack of funds to pay off debt.

In the process of paying off the mortgage debt, the actual property rights of a real estate acquirer grow since in the volume of these rights unpaid debt decreases. However, from the point of view of use, such a right for an acquirer arose from the moment of receiving a loan sent by a bank in favor of the real estate seller (Lampe and Würtenberger, 2020). This means that, despite the partially redeemed property, the property interest in its preservation takes place from the moment such use begins, and according to the right of use, such interest is generated.

The buyer is interested in maintaining the quality of their lives, which implies the preservation of appliances and furnishings. If the equipment and furnishings of the apartment were purchased by the buyer after one obtained the right to use it, the reasons for this interest become more obvious. At the same time, the risk of losing the property rights paid for under the mortgage agreement is particularly felt after it has been concluded since the right to use the dwelling is particularly acute in the first period after acquiring the right, which can easily be compared to the acquirers' quality of life. This reasoning is described by the positive value of the function in the first quarter of the coordinate axis. If one considers debts for purchased housing as liabilities, or losses, the sensitivity to the risk of inability to recover them increases as the debt itself decreases. The risk of loss of income on mortgage debt repayment at the beginning of the contract is felt less acutely by the borrower, and the sensitivity to this risk is lower because the amount of contributions paid does not appear to be significant.

The function of the unpaid debt value as a reflection of the losses is in the third quarter of the coordinate plane, being negative. Since the end of the mortgage contract corresponds to the complete exhaustion of the obligations, i.e., the value of the anti-benefits is "zero", the beginning of their fulfilment will be earlier than the end of the mortgage contract. Assuming that the contract ends at point zero, its beginning should be considered the negative value of the abscissa axis as the beginning of the interval from the value N to the value 0 if N equals the term of the contract.

The sensitivity to risk creates the need for insurance because insurance is an instrument of transferring risk from its bearer to the insurance company. Consequently, the need for insurance can be a reflection of the amount of capital or losses: the higher the rate of change of this function (its first derivative), the higher the sensitivity to risk and the growing insurable interest.

3.2. Research hypothesis

The study purpose – by representing the insurance needs of the mortgage holder in the form of a value function, the study formulates a hypothesis about the optimal zone of insurable interest of the borrower under the mortgage contract. The model is important as an opportunity to get a tool for shaping approaches to insurance strategy and real estate management to ensure the interests of both purchasers and creditors during the crisis period.

In the initial period, after entering into the right to use the home, the sensitivity to the risk of not paying the debt according to the value function is low, and the insurable interest in it grows slowly, as the buyers do not yet feel the value of the home for themselves and the additional investment in it. At the end of the mortgage contract, the more the buyer pays down the debt, the greater the risk of not being able to make the payment at the end of the mortgage, which means that the value, the utility of the home purchased increases. The willingness to ensure obligations under a mortgage contract is likely to grow as well.

3.3. Study design and data analysis

To test the hypothesis, it was decided to use the data from the US mortgage market in the period 2009-2019, namely, mortgage insurance contracts. During the analysis, data on mortgage agreements concluded in 2009 for 10 years were used. The share of insurance premiums under such contracts in the total premium collections for each year is analyzed. The source of information was the research of analysts published on Statista and ReportLinker (Tsindeliani et al., 2022). They made it possible to collect a substantial amount of data (10 years) from open sources, which, unfortunately, is not possible in the practice of other markets. There were no additional requirements for the selection of insurance contracts included in the analysis. The main purpose was to collect the maximum amount of data for better objectivity.

The study period was chosen due to the fact that after the global financial crisis of 2008, the mortgage market was actually “zeroed”, which made the data on its development in 2009 clear of financial flows not accompanying mortgage agreements. The study has taken into account that mortgage rates are tied to the basic rules of supply and demand. Among the main influencing factors, including in this study, are inflation, economic growth, the monetary policy of the Federal Reserve, and the state of the bond and housing markets. The explanation for the choice of empirical data for the study of the US is that it is not only the most developed mortgage market in the world but also the center of major financial crises (Quillian et al., 2020; Rudden, 2019). Therefore, this array is assumed to

be the most representative. It is considered justified to test the developed model of homeowners' interest insurance on the array of US housing market data.

3.4. Research tools

For modelling, the IT tool "Approximation of one variable function" was used, which enabled formulating a description of a function by points. For calculations, MATLAB - a package of application programs for technical calculations - was used. As a result, an approximating function that, in general, is closest to the given points (or to the given continuous function) was built, the influence of errors in the initial data was eliminated, and a simplified mathematical description of a complex or unknown dependence was obtained, which makes the proposed tool quite simple to use. Simulation of processes in time series was performed by drawing a curve through experimental points on the plane. In this case, the tool was used to find the function's expression and approximate the studied data (the dynamics of the share of insurance premiums on the studied contracts in the company portfolio).

The dynamics of the usefulness of property rights acquired under a mortgage agreement were assessed by analyzing the demand for their insurance:

- approximation errors (to identify possible inconsistencies between the exact value and some approximation to it);
- correlation coefficient (to identify the statistical relationship of random variables);
- the determination coefficient (to determine the variance of the dependent variable explained by the considered dependence model, that is, by the explanatory variables of the constructed model).

4. Results

Based on the proposed methodology, insurance contracts for property rights acquired under a mortgage agreement are considered separately from insurance contracts for the risk of inability to fulfill credit obligations. The share of insurance premiums in the FHA[1] portfolio under agreements concluded between 2009 and 2019 by borrowers who entered into mortgage agreements in 2009 was considered as the insurance value for the borrower.

Table 1. The average share of insurance premiums under insurance contracts for furnishings and equipment of a house acquired on a mortgage in 2009 in the portfolio of the US Federal Housing Administration (FHA)

year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
share%	1.5	3	4.1	4.4	4.1	4.6	4.8	3.9	4.57	4.86

[1] FHA - The Federal Housing Administration (FHA) is a US agency that offers mortgage insurance to FHA approved lenders who meet certain requirements. Mortgage insurance protects lenders from losses from mortgage defaults. If a borrower defaults on the loan, FHA will pay a lender the specified amount of the claim (https://www.investopedia.com/terms/f/federal-housing-administration).

Assuming that over the 10 years of the mortgage contract, the amount of paid housing rights increases and the share of insurance premiums in the portfolio visualizes this, one can assume the existence of a relationship between the amount of paid mortgage loan and the demand for purchased insurance. The construction of the demand curve for home insurance based on the data in Table 1 reveals such a dependence. The curve (Figure 3) reflects the growth of the value (utility) of the mortgage subject as it is redeemed. The change in premium growth in the FHA portfolio is visualized as a function of the length of insurance contracts. The rate of increase in sensitivity to the risk of capital gains is particularly high when capital gains are small, and the rate of increase in sensitivity to the risk of increasing debt changes rapidly when it is small. At the beginning of the period, premiums grow very intensively, and during the period the rate of growth declines. Interest in insurance coverage for mortgage property declines as the debt is repaid. This may seem absurd but is explained by the fact that the loss of the purchased home is less tragic than the loss of both the house and the mortgage on the defaulted loan at the beginning of the mortgage agreement. At the beginning of the contract, the acquirer will lose the residence and the ability to repay the mortgage loan, so property insurance is more in demand during the first period of the contract.

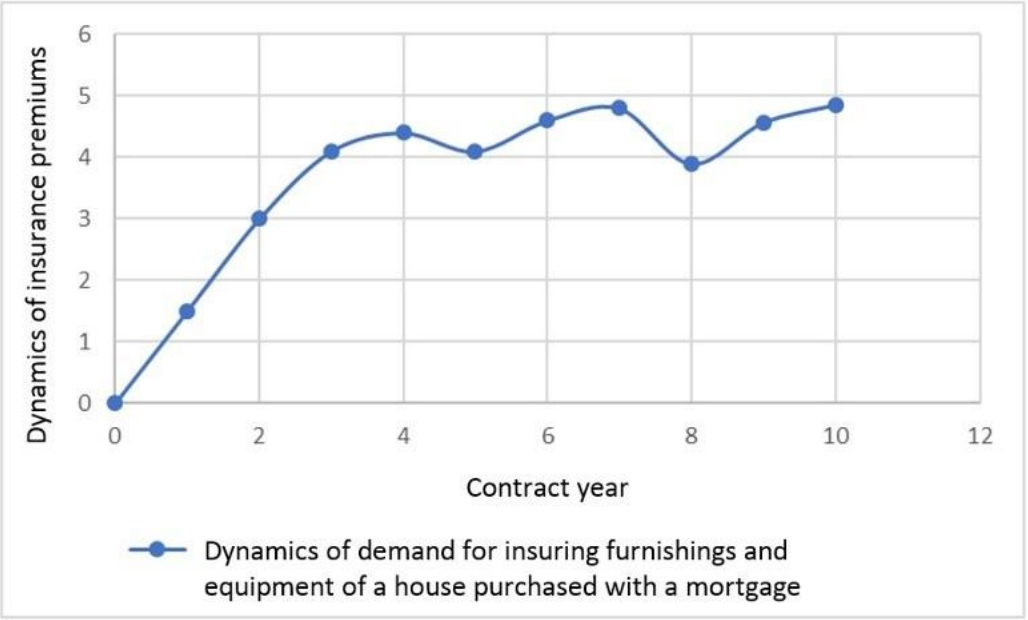

Figure 3. Demand curve for insurance of property rights acquired under a mortgage agreement
Source: Rudden (2019).

It is indicative that the constructed graph is similar to the “value curve” of acquired wealth described by Kahneman and Tversky. This correspondence of theory and practice substantiates the proposed description of the utility function of acquired wealth and proves its correspondence to practical data by evaluating the adequacy of these functions by

calculating the corresponding coefficients. Their value confirms this adequacy. The assumption, as stated in the study hypothesis, posits that the mortgage insurance consumer's inclination to purchase insurance increases in proportion to their perceived usefulness.

At the next stage, the hypothesis is tested on the correspondence of the utility functions of property rights acquired under a mortgage agreement to the natural logarithm (Kahneman, 2013; Radiany et al., 2020), which is consistent with the theory of expected utility (Bernoulli, 2011), according to which, as already mentioned, the wealth function is traditionally logarithmic. Using the dynamics of the share of insurance premiums for the studied contracts in the company's portfolio and the IT tool "Approximation of one variable function", a function has been found that accurately approximates the investigated data. Based on the data in Table 1 on the dynamics of insurance premiums shared under the studied contracts in the company's portfolio, a function is determined that describes these dynamics as accurately as possible:

$$U(X) = \ln(x+0.07) + 2.65926 \quad (1)$$

Its graph is presented below, in Figure 4.

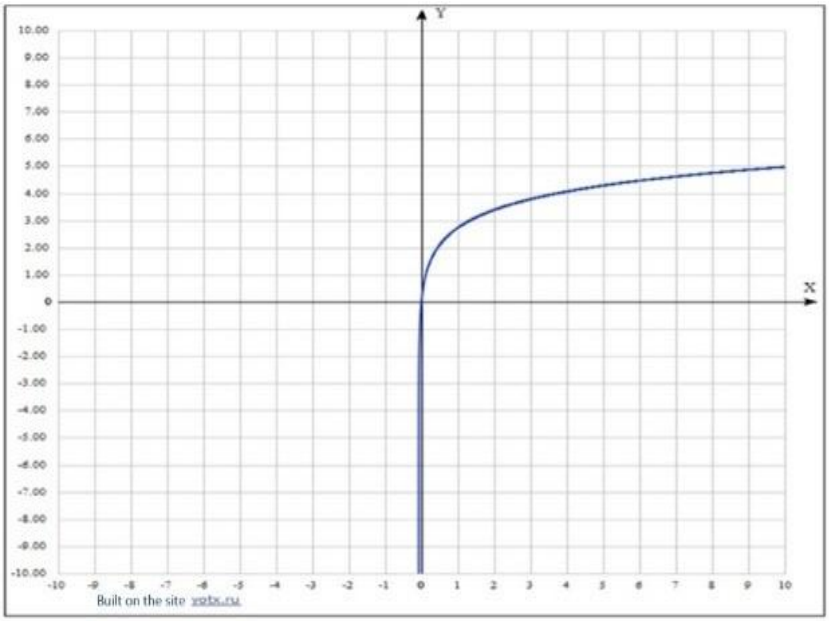

Figure 4. The graph of the utility function of insurance of property rights to real estate acquired under a mortgage agreement.
Source: developed by the authors.

The figure shows that, first, the intensity of insurance changes as the debt is paid. However, in the beginning, when the debt is large, the amount of insurance coverage purchased grows slowly. As the paid-in portion grows and the debt decreases, the intensity of insurance increases because the property can be foreclosed regardless of the defaulted loan amount, so the fear of losing a home that is almost paid for forces the owner to insure against financial problems. Interestingly, Kahneman and Tversky (1979) define this attitude

to possible losses by their function of value. This assumption, which is based on the existing research theory, thus found its support in the calculations.

It is important to note that in essence of the subject of analysis, the range of values of this function is only the positive range.

$Y \geq 0.$

For each year, the found function was used to calculate the theoretical values (which characterize the usefulness of the acquired property rights) of the share of insurance premiums in the portfolio and compare them with the actual values of the indicator. Table 2 presented a comparison of the actual and theoretically obtained values of the share of insurance premiums for mortgage housing insurance during the period of the mortgage agreement.

Table 2. Data for checking the adequacy of the created model of acquired property rights utility dynamics (under a mortgage agreement)

year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
share% fact	1.5	3	4.1	4.4	4.1	4.6	4.8	3.9	4.57	4.86
share model	2.727	3.387	3.781	4.063	4.282	4.462	4.615	4.747	4.864	4.969

Further, based on the average approximation error, correlation and determination coefficients, obtained theoretical values were compared with the actual values. The following values of the calculated coefficients were obtained (Table 3).

Table 3. The assessment of the adequacy of the model describing the dynamics of the utility of property rights acquired under a mortgage agreement by assessing the demand for their insurance

Approximation error	Correlation coefficient	Determination coefficient
0.152867	0.889048	0.69913
average	high	middle

The quality of the model is sufficient, and it confirms the hypothesis about the maximum growth rate of demand for mortgage home insurance at the stage of 30-35% of the contract period. It was found that the growth rate of insurance demand was highest in 2009-2011, which corresponds exactly to the specified stage of 30% to 35% of the contract period. The results are consistent with Kahneman's assumptions about the overestimation (weight) of small risks (Kahneman, 2013). A similar procedure was conducted to analyze the hypothesis of increasing sensitivity to the risk of default on the mortgage contract as it approaches completion. Failure to make the last payments may result in the loss of the housing that is almost purchased.

The requirement to ensure the risk of non-fulfilment of these obligations must correspond to the value of losses in case of impossibility of their fulfilment. If considering the value of premiums under the insurance contracts as the value of losses, the value of

already fulfilled obligations under the expired loan contract is equal to the amount of payment under the insurance contracts concluded during this period. Thus, borrowers insure their liability for non-payment of each regular annual payment. The amount of losses caused by another non-payment increases during the term of the contract, it is minimal at the beginning and maximal in the last year. The dynamics of insurance premiums can be analyzed by data on the share of insurance premiums paid in the total portfolio of the company.

The activity of mortgage loan purchasers ensuring their liability to the lender for non-payment of the loan was analyzed further. By analyzing the average share of premiums under these contracts in the portfolio depending on the term of insurance contracts, as well as the dynamics of its change, the curve of total premiums change for this type of insurance depending on the volume of overdue loans was built.

Data from the U.S. Federal Housing Administration support this thesis (Table 4). The table is calculated similarly to Table 1.

Table 4. The average share of liability insurance premiums for mortgage-backed borrowers in 2009 in the portfolio of the US Federal Housing Administration (FHA)

year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
share%	0.01	0.05	0.5	0.01	0	0.977	0.308	0.68	0.543	3.195

Further, the borrower was considered as a person having debt at the time of the conclusion of the mortgage agreement. The essence of debt is the opposite of the essence of capital. If capital is good and its value is determined by its utility, which has positive values, then debt is an “anti-good”, and its utility is negative. At the same time, the absolute value of the “anti-good” decreases as the debt decreases. The total utility of the debt at the time of its occurrence can be considered as the value of all paid insurance premiums. This is the sum of all the values in Table 4. It is equal to 6.273, taken with the opposite sign, that is, “anti-good” has “anti-usefulness”.

Based on the data in Table 4, the dynamics of forthcoming obligations’ value should be calculated as the amount of insurance premiums paid for the remaining period of the contract validity at each moment of analysis. Since liabilities are an “anti-benefit”, their value is negative. That is, the order of calculation in Table 5 has the following logic:

-6.273 + 0.01 = -6.263

-6.263 + 0.05 = -6.213 … etc.

As a result, the following value dynamics were obtained (Table 5).

Table 5. The dynamics of the value of unfulfilled obligations (losses) on the purchase of housing in a mortgage, as the share of insurance premiums on insurance of liability of the borrower in 2009 in the portfolio of the US Federal Housing Administration (FHA)

year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
share%	- 6.273	- 6.263	- 6.213	- 5.713	- 5.703	- 5.703	-4.726	- 4.418	- 3.738	- 3.195

If one builds a graph of the value function of upcoming obligations, then the point of its beginning will be in the negative area, for a period less than the end date for the contract period. This means that the domain of definition of the liability value function is located in the interval -10≤x≤0, the range is also negative since the graph reflects the value of the "anti-benefit". Therefore, a value function reflects the value of "anti-benefit" in the lower left quarter of the coordinate system. The graph of the function of unfulfilled obligations' value as the cost of insurance premiums paid for the coming period, based on the data in Table 5, is as follows (Figure 5).

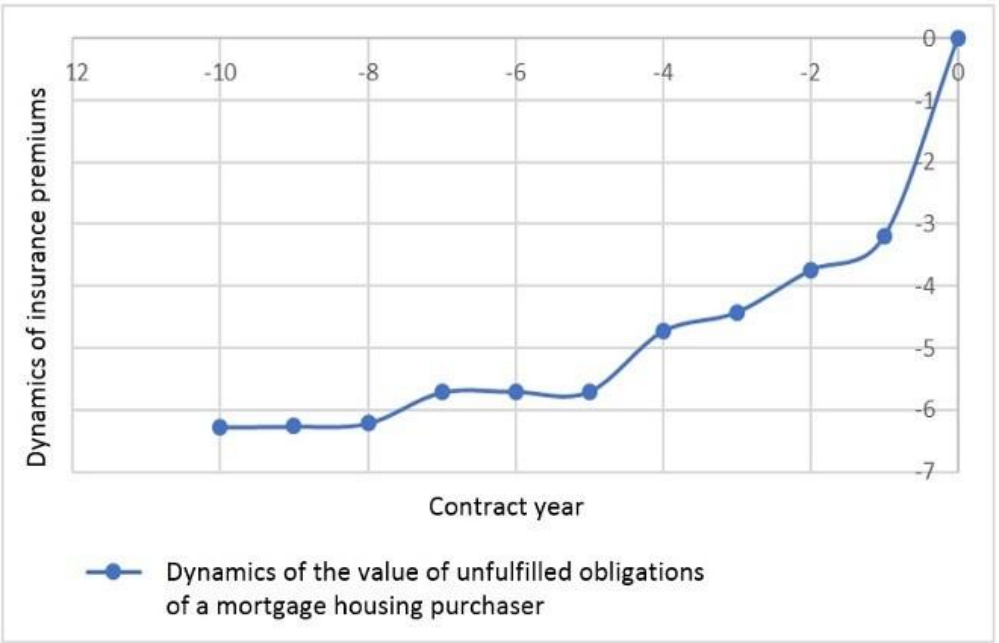

Figure 5. Demand curve for liability insurance for default under the mortgage agreement
Source: Rudden (2019).

The hypothesis was tested about the possibility of describing the value function of forthcoming obligations by an exponential function, as inverse to the logarithmic function, since losses are the opposite of the acquisition of rights. By the available values and the use of the IT tool "Approximation of one variable function", the expression of the required function is found:

$$U(X) = EXP(x+3.785/2)-6.635938 \quad (2)$$

Its graph is shown in Figure 6.

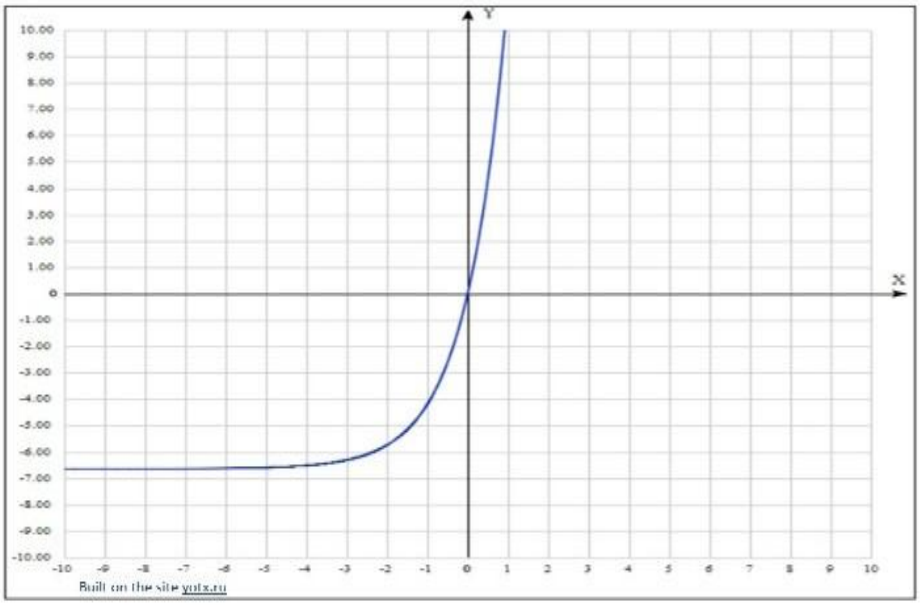

Figure 6. The graph of the utility function of liability insurance for default under the mortgage agreement.
Source: developed by the authors.

The range of values of the demand function for insurance is always negative or equal to zero.

$Y \leq 0$

The combination of functions that reflect demand as an expression of utility and value is a reflection of the value function of Kahneman and Tversky (2003) in accordance with the theory of prospects and is graphically represented as follows (Figure 7).

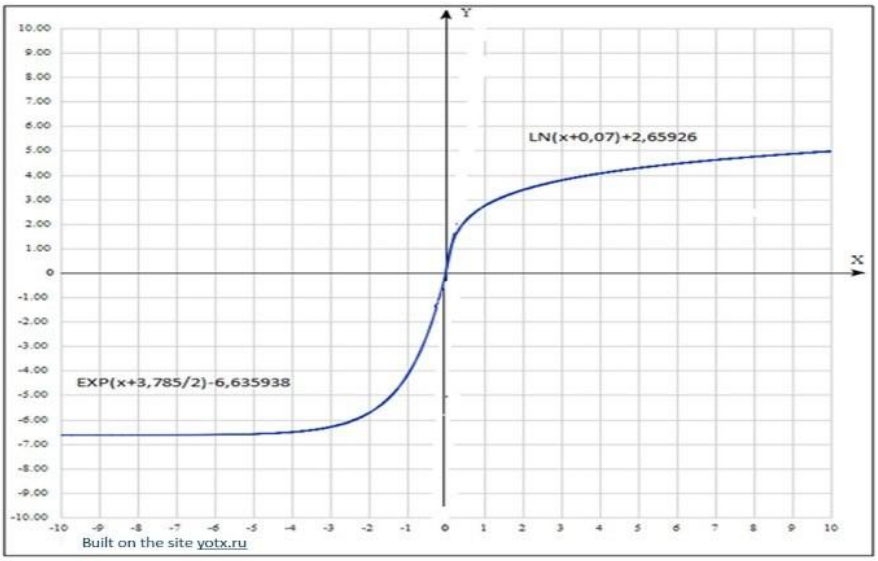

Figure 7. The graph of the insurance value function for a home purchaser under a mortgage agreement. *Source:* developed by the authors.

Based on the model, it has been decided to calculate the theoretical values of the indicator (that characterizes the value of unfulfilled obligations at each moment of the analysis) and compare them with the actual values of the indicator (Table 6).

Table 6. Data to verify the adequacy of the created model of the value of the default obligations of borrowers under a mortgage agreement

year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
share%	-	-	-	-	-	-	-	-	-	-
fact	6.273	6.263	6.213	5.713	5.703	5.703	4.726	4.418	3.738	3.195
share	-	-	-	-6.63	-6.62	-	-	-	-	-
model	6.636	6.635	6.634			6.591	6.514	6.306	5.738	4.195

Further, the share of liability insurance contracts of borrowers under a mortgage contract in the FHA insurance portfolio was assessed. The model was evaluated based on the average approximation error, correlation and determination coefficients. The following values of the estimated coefficients were obtained (Table 7).

Table 7. The assessment of the adequacy of the model describing dynamics of the value of the default obligations of a borrower under the mortgage agreement based on the dynamics of the insurance premiums paid for default obligations' insurance in the FHA portfolio

Approximation error	Correlation coefficient	Determination coefficient
0.17466	0.83614	0.69913
high	high	middle

The model's quality can be considered sufficient. It confirms the hypothesis about the maximum growth of the need for ensuring outstanding obligations under the mortgage contract already at 33% of the term of the dwelling's use. The main interpretation of the resulting graph and the model is as follows: depending on the mortgage contract's term, the aspects of interest in insurance protection change, as the source of possible losses changes. At the beginning of the contract term, the subject is interested in preserving the property because its loss in case of default would cause him/her a double loss: the loss of the home itself and the loss of the mortgage collateral. As the mortgage loan is repaid, the second role of the property (as collateral) becomes less and less important as the debt decreases. The steepness of the value curve in the first quarter of the coordinate system shows a rapid increase in the value of the property rights being purchased at the beginning of the mortgage agreement. The interest of a mortgage contract subject to fulfilling their obligations to the end is much lower at the beginning of the contract, and the risk of losing an almost unpaid home under a mortgage contract is not much of a risk. It follows that in the beginning the need for financial insolvency risk insurance is rather small, and the value curve grows slowly. However, as the debt is repaid, the risk of not being able to make a regular payment at the very end of the contract period increases, because the house may be foreclosed on, despite the small debt. Therefore, when the value of the debt is close to 0, the value of the obligation increases, and insurance is in demand during this period.

4.1. Practical implications and managerial implications

The practical managerial value of the results obtained lies in the possibility of significant optimization of insurance strategy and real estate management of insurance companies in the real estate market at the same time. At the same time, the proposed calculation method and model are beneficial for the mass mortgage user, satisfying the needs of the increasing mass of home loan users who use electronic financial programs and lending platforms to avoid risks and obtain more reliable loan repayment models. In social and governmental terms, this ensures a higher level of controllability of the credit sector and avoids the risks of bubbles in the market, preventing social conflicts and the sustainability of economic development.

Contributing research to the body of knowledge is to use several new tools and approaches in modelling the risk reduction of real estate purchase insurance for a retail user, based on the psychology of a new generation of users armed with FinTech tools and wider access to the market. The use of these approaches, according to the authors, provides the opportunity to expand the real estate mortgage market to wider social strata and improve insurance conditions in general.

5. Discussion

The variety of demand patterns for home purchase insurance under mortgage agreements is not enough in the current expansion of the market for electronic means of processing large amounts of data and services offering online financial services. The analysis of theoretical sources demonstrates the insufficient attention of economic science to this area and its practical application. The relevance of the current study and the findings is that it simplifies and speeds up the process of assessing the effectiveness of risk insurance for the end user. And at the same time, this model, compared to other described approaches, can be more easily used in the field of online financial services.

Demand from the real sector of the economy is very strong and the need for rapid assessment and insurance of risks for households will only grow in anticipation of a possible deepening of the recession. Most studies of homebuyers under a mortgage agreement highlight a number of narrow aspects of this problem (Lampe and Würtenberger, 2018) or analyze only selected markets without taking into account several new factors affecting household investment (Jayasuriya et al., 2022; Ojo et al., 2022). The proposed model generalizes these observations and can be used to account for these new factors.

Relevance and novelty of this research this study lies in the construction of several different approaches to mortgage analysis and leans toward the view that the digital footprint (DF) helps reduce lender risk and may generate social benefits from reduced discriminatory power. The borrower's DF can generate a significant information advantage, which is typical for most modern digital tools, and it far exceeds the advantages offered by traditional lending methods. However, it should be taken into account that, as shown in our study, such an advantage may be temporary or imperfect due to the rapid spread of informational assessment tools. The focus of our article is markedly different and focuses

on modelling the demand function for insurance driven by borrowers' desire to mitigate the risk of loss. This is opposite to the use of digital tools that provide an advantage and, therefore, provoke a desire for gain or reduction of fears, which may not be justified (Renigier-Biłozor et al., 2021; Ullah et al., 2021).

The study by Goldstein and DeMaria (2022) addresses small-dollar mortgages in Pennsylvania, New Jersey, and Delaware. The previous researchers have provided an in-depth and detailed analysis of mortgages of $100,000 or less (small-dollar mortgages) in Pennsylvania, New Jersey, and Delaware between 2019 and 2021 (Goldstein and DeMaria, 2022). It should be noted that the research emphasizes issues of discrimination in obtaining mortgage loans. This research preference causes differences in the results obtained. The finding of such a difference suggests that the use of the model proposed here allows, in principle, the analysis to also identify discriminatory practices prior to investment. This determines the additional relevance of the proposed model and approach.

Some researchers rightly point out that government interventions in mortgage refinancing activities and efforts to stimulate consumption primarily in the area of affordable housing significantly change real-market demand patterns. The life cycle of the refinancing model should include the expected reduction in competition as a result of government intervention, and in such a case can generate welfare gains from these changes. Models that quantitatively rationalize the basic laws of mortgage lending should, as the result obtained in the study proposed here, shape their approach from the point of view of reducing the risk on the part of the borrower.

The results obtained once again confirm the data of many other previous researchers, indicating that the most important factor in the development of the mortgage insurance industry is an accurate understanding of the unmet needs and fears of borrowers (Kwon and Wolfrom, 2017). The motivation of insurance demand, to reduce risk or increase the expected benefit, which underlies the approach, actually determines the real quality of predicting the needs of market participants. Kwon and Wolfrom (2017) emphasize that knowledge and anticipation of insurance demand in the mortgage market allow the creation of specific convergent insurance products that can sufficiently and more quickly satisfy the maximum insurance demand. The results obtained can also be seen as confirming the need to actively use insurance instruments as a bailout for risk-prone borrowers, despite the fact that this may seem disadvantageous. Refusal of such assistance negatively affects the ability of a manager or company to effectively minimize losses and efficiently manage overdue payments through loan modification and foreclosures (Cabral et al., 2019; Kovacs and Pasztor, 2019).

Some researchers have also confirmed that as behavioural models become more integrated into economics and finance, insurance markets experience their effects. At the same time, the study of the prospect theory confirms the main postulates of the demand for insurance. The result is consistent with the conclusions of a simple model with two stages and fair insurance contracts. The researchers have established that for both stages, subjects require either full insurance or no insurance at all, and the higher the probability of losing the higher the propensity for insurance. People are reluctant to insure rare losses through subsidized premiums (Brener, 2020). The conclusion that insurance contracts should consider the needs of the insured person is confirmed by the results of the article.

The results prove that the parameters of the insurance contract are adjusted to better match a policyholder's preferences, therefore, it is proposed to draw up insurance contracts exactly according to these needs (Tsindeliani et al., 2021).

The proposed study develops the postulates formulated by Kahneman and Tversky (1979) and does not use their theory in the original. Reassessment of small risks, using the example of changes in the mortgage insurance market, is an important requirement of the real market situation and economic changes that property managers face. The need to fulfil obligations and preserve wealth is considered in the context of increased volatility and increased unpredictability of risks (Bhutta and Keys, 2022). Further development of the theory of Kahneman and Tversky is confirmed by the fact that debt repayment leads to an increase in the utility of the outstanding debt for the mortgagee because it becomes more and more unprofitable for him to lose real estate, an increasing part of the value of which has already been paid.

The tentative assumption of a higher growth in the need for non-performing mortgage contract insurance has already been confirmed by 33% of households. This situation corresponds to the postulate of Kahneman and Tversky (1979) about the overestimation of small risks. The study presented here demonstrates results that support a working model that can efficiently rebalance the value of real estate and more effectively calculate the risks of a mortgage sale contract. A number of studies can be considered polemical about the results obtained (Allen et al., 2023; Dalhaus et al., 2020; Haupert, 2022; Liu et al., 2022). However, all of them rely on an assessment of demand from the borrower's desire for greater current benefit, rather than the desire to reduce risk, which seems to be a much more adequate approach.

6. Conclusions

The study reveals varying degrees of willingness to purchase insurance coverage and proposes an approach that combines a quantitative and qualitative assessment of the economic and cultural phenomenon of "consumption" in the mortgage insurance market. It has proven effective in shaping an insurance strategy based on the needs of mortgagees to manage their assets. It is concluded that the aspects of interest in insurance coverage shift as the mortgage contract is executed. At the beginning of the contract, the risk of losing an almost unpaid home poses little risk, which explains the low interest of the subjects in fulfilling their obligations. During this period, the need for financial risk insurance is relatively low. The more a mortgage buyer pays off debt, the greater the risk of being unable to make a payment and even a small debt can lead to foreclosure. The closer the amount of debt to 0, the higher the value of the obligation and the greater the demand for insurance.

The correlation between the size of the repaid mortgage loan and the demand for home mortgage insurance during the period of the mortgage contract, during which the amount of paid housing rights increases, is demonstrated. The increase in demand for insurance turned out to be maximal during 30-35% of the term of the contract. Consequently, the hypothesis of willingness to ensure obligations under the mortgage contract and

willingness to insure the home itself was confirmed. It can be assumed that losses from non-payment increase over the life cycle of the mortgage contract.
The theoretical significance of the work lies in the further development of the theory of prospects. First of all, this is about the aspect of reassessment (weighing) of small risks, also attention is paid to the development of behavioral economics postulates by studying the relationship between psychological factors and the decisions taken in the example of the mortgage insurance market. The practical significance of this study and its conceptual differences from more "labour-intensive" implementation models consists in obtaining a simple and reliable tool for management decision-making in segments related to the real estate market. It allows for rational measures to be taken to ensure an appropriate insurance and real estate management strategy that takes into account the interests of both borrowers and lenders. The proposed model will allow for a rebalancing of property values and calculating the risks associated with the sale of a mortgage loan agreement. Mortgagees can use it for each subsequent mortgage or to figure out a profitable time to get rid of assets. Insurance companies and lenders can calculate the need for insurance and predict when mortgage buyer activity will increase. Banks can use this model to account for the potential magnitude of losses from another default during the life cycle of a mortgage contract.

6.1. Research limitations

One of the main study limitations that do not allow classifying its results as generalizing is the institutional factor – as already demonstrated in the introduction, the US mortgage market has significant differences from other markets in the principles of regulating the lending rate and the essence of mortgage loans. Institutional forces in the US may even have a greater influence on insurance decisions than consumer risk tolerance. The launch of mortgage insurance programs is carried out by state institutions. As emphasized in the theoretical part, in the United States, lenders do not leave mortgage loans on the balance sheet and do not issue mortgage securities backed by them but delegate this function to intermediaries who raise funds through investors in the bond market. Besides, the features of mortgage lending in the United States include a developed refinancing system; a low annual interest rate; and active work of US banks to provide mortgage loans to buyers both in the primary housing market and in the secondary one. In the US, a borrower has also the possibility to choose a bank with more favorable conditions for an initial payment. However, due to the proven quality of the proposed and tested model, it can be assumed that it works in other mortgage markets as well. In further research, the authors can test the model on a different dataset.

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