Available online at http://www.iorajournal.org/index.php/ijgor/index

International Journal of Global Operations Research

e-ISSN: 2722-1016
p-ISSN: 2723-1739

Vol. 6, No. 1, pp. 13-17, 2025

Application of Mathematical Models in Creating Optimal Strategies to Reduce Home Ownership Credit Costs

Fathin Alifah[1*], Kayla Nurul Kurniasih[2]

[1.2]*Department of Mathematics, Faculty of Mathematics and Natural Sciences, Padjadjaran University*
Jl. Raya Bandung Sumedang KM.21, West Java 45363

Email: fathin23002@mail.unpad.ac.id

Abstract

Home Ownership Credit (KPR) is one of the important financing options for people who want to own a home. However, the total amount to be paid during the loan period is high, which is why for many borrowers this study aims to apply mathematical models to develop optimal strategies to reduce the overall mortgage entry costs. This study uses the annuity concept to model installment payments by considering factors such as interest rate, term, and payment frequency. The model also considers repayment scenarios that include early repayment options to reduce long-term interest costs. Simulation results show that by choosing a shorter period and using early payments in certain periods, significant overall cost savings can be achieved. In addition, although variable interest rates are riskier, they have been shown to offer greater savings potential than fixed interest rates under certain economic conditions. The conclusion of this study is that the application of an optimal payment strategy through a mathematical approach can significantly reduce total mortgage costs and provide long-term benefits to borrowers.

Keywords: Mortgage, annuity, interest rates, payment optimization, mathematical models.

1. Introduction

Home Ownership Credit (KPR) has become an important way to purchase property, especially for people in countries with low home ownership rates (Nasution, 2021). However, financing through KPR can incur significant interest costs, especially in the long term, as well as installment payments. Borrowers often pay much more than the original price of the property and require a more efficient payment strategy. Various factors such as interest rates, terms, and payment frequency have a significant impact on the total cost paid (Hancock, D., & Humphrey,1997).

On the other hand, options such as early repayment and shorter terms are often overlooked by borrowers because they do not understand the mathematical meaning of these strategies. Financial institutions currently offer a variety of fixed and variable interest rate schemes, each with its own advantages and disadvantages, but there is no clear guideline for determining which strategy is the most financially efficient. In this context, applying mathematical models to analyze and optimize mortgage payments can provide borrowers with more measurable and targeted solutions (Mbillwe, S. K. (2006).

There are several studies related to the application of mathematical models in developing optimal strategies to reduce the cost of home ownership loans, which in this study. For example, KOMIK (2017) conducted an analysis of several approaches found, including methods such as Analytic Hierarchy Process (AHP) and MOORA (Multi-Objective Optimization with Ratio Analysis). This helps in the process of selecting alternatives based on the alternative selection process. The decision is based on criteria such as salary level, number of dependents, and number of loan applications. For example, in MOORA, priorities are determined by comparing various alternatives based on certain weighted criteria. Another approach that can be considered is the use of Monte Carlo simulation techniques or genetic algorithms (GA) to predict risks and optimize financial strategies related to mortgage loans. Although Monte Carlo simulations are often used to predict long-term cost changes, genetic algorithms can be applied to find optimal solutions for more efficient mortgage payment arrangements.

2. Literature review

2.1. Annuity Model for Credit Payment

The concept of annuity is the main approach in modeling mortgage installment payments. Annuity is a fixed payment method, where the interest and principal components change throughout the loan term. Several studies, such as those conducted by Kumar et al. (2015), highlight the importance of annuity in calculating long-term liabilities. This model allows borrowers to understand the distribution of interest and principal payments, thus facilitating the evaluation of the total cost of the mortgage.

2.2. Simulation and Optimization of Payment Strategy

Several simulation approaches have been used to analyze mortgage payment scenarios. Monte Carlo simulation, as implemented by Wang et al. (2021), allows for long-term cost predictions based on different interest rate scenarios. By generating thousands of simulation scenarios, this approach helps analyze the risks and opportunities faced by borrowers related to variable interest rates, especially in volatile economic conditions.

2.3. Research Gaps

Although various methods have been used to analyze and optimize mortgage payments, many borrowers still have difficulty implementing these strategies in practice. In addition, studies that integrate various mathematical approaches such as Monte Carlo simulation, annuity models, and linear optimization have been used separately, integration. These three approaches are still rarely used. Therefore, this study attempts to fill this gap by developing a model that integrates various approaches to produce an optimal and practical payment strategy. Monte Carlo simulation provides insight into the risks and opportunities associated with variable interest rates, while the annuity model provides a clear structure in loan payments. Meanwhile, linear optimization offers a mathematical solution to determine a more efficient payment strategy. Research by Zhao et al. (2021) emphasizes that combining these approaches produces a more effective payment strategy compared to applying each approach individually.

3. Materials and Methodology

3.1 Material

This study was conducted using relevant data and information related to Home Ownership Credit (KPR) in Indonesia as the basis for analysis. The data analyzed includes KPR simulations from several financial institutions that offer fixed and variable interest schemes. This study is a simulation, so it is not conducted in a specific physical location. However, the data used is obtained from financial institutions based in Indonesia. The data to be used are historical interest rates from Indonesian financial institutions, KPR installment payment simulations with various scenarios, and economic statistics that influence interest rate.

As an analysis tool, this study utilizes software such as Microsoft Excel and Python. These tools are used to perform Monte Carlo simulations and linear optimization, which are the main components in the data analysis process. Mathematical calculation methods such as annuity formulas are used to model installment payments, while Monte Carlo simulations help analyze variable interest rate risks. Linear optimization models are used to determine more efficient payment strategies.

3.2 Methodology

This research will conduct data analysis first involving data collection, processing, and evaluation aimed at producing an optimal strategy in reducing the total cost of Home Ownership Credit (KPR). The data used includes historical information on interest rates, installment payment simulations, and economic scenarios related to KPR.

3.2.1. Structure

Collecting information related to mortgage payment schemes (fixed and variable interest) from financial institutions also reviewing previous studies discussing annuity, Monte Carlo, and linear optimization models to identify relevant approaches.

3.2.2 Formula / Equation

3.2.2.1. Annuity model:

$$PMT = \frac{P.r.(1+r)^n}{(1+r)^n - 1}$$

- P: Initial loan principal.
- r: Interest rate per period.
- n: Total payment period.

3.2.2.2. Monte Carlo Simulation

Simulate various variable interest rate scenarios using probability distributions. By first determining input variables such as interest rates, inflation, and others. Then determining the probability distribution for the interest rate and finally iterating to produce the total mortgage cost distribution. The results of this simulation are insights into the risks and opportunities associated with changes in interest rates.

3.2.2.3. Linear Optimization

Determine an early repayment strategy with the aim of minimizing the total interest paid by

$$Z = \sum_{i=1}^{n} B_i \, . x_i$$

Where is the interest in the period and is the Decision variable (amount of early repayment). Along with the constraints in the total early repayment that does not exceed the budget. Also, repayment is only made in certain periods.$B_i ix_i \sum_{i=1}^{n} \quad x_i \leq Anggaran\ Maksimal$

3.2.2.4. Model Validation

Test the sensitivity level of the model to changes in inputs, such as interest rates, terms, and early repayment budgets, and compare simulation and optimization results for various fixed and variable interest scenarios.

3.2.3 Tables

In calculating annuities, a formula is used which consists of the period, payment, interest, principal, and also the remaining debt as follows:

Table 1: Annuity Calculation

Period	Payment (PMT)	Flower	Main Point	Remaining debt
1	5,000,000	2,000,000	3,000,000	97,000,000
2	5,000,000	1,940,000	3,060,000	93,940,000

After calculating the annuity and conducting a simulation using Monte Carlo, an early payment strategy will be designed to minimize the total interest using the linear optimization formula:

Table 2: Linear Optimization Calculation

Period	Flower	Early Settlement	Total Interest
1	2,000,000	10,000,000	90,000,000
2	1,940,000	5,000,000	85,940,000

4 Results and Discussion

Simulation using an annuity formula produces a distribution of monthly installment payments. It can be seen in Table 1 which is the Annuity Calculation Result. From the simulation results, it can be seen that the interest component decreases each period, while the principal component increases. This pattern indicates that the principal payment is greater in the next period. Then the results of the simulation using Monte Carlo are carried out using the interest ratevariable. Thousands of iterations produce a probability distribution graph showing the various possible total mortgage costs based on interest rate fluctuations. The main results of the Monte Carlo simulation are as follows:

- The average interest rate is 8%.
- Interest rate ranges from 6% to 10%.
- Total mortgage costs under high interest rate conditions (10%): IDR 1.2 billion.
- Total mortgage cost under low interest rate conditions (6%): IDR 1 billion.

And the risk picture obtained in the form of a high interest rate results in a total cost increase of 20% compared to the low interest rate scenario. Furthermore, linear optimization is carried out by designing an early repayment strategy resulting in a significant reduction in total interest with the results of the optimization can be seen in Table 2. By implementing early repayment in the early period, the total interest can be reduced by up to 10%.

The application of mathematical models such as annuity, Monte Carlo simulation, and linear optimization can provide optimal strategies to reduce the cost of Home Ownership Loans (KPR). Each approach provides unique insights, which when combined, can provide a comprehensive solution for borrowers. The annuity model provides a clear picture of the distribution of payments over the life of the loan. In the early stages of the loan, the interest portion of the payment is greater than the principal portion. However, over time, this proportion reverses, with the principal component increasing. This shows that if the borrower makes early repayments in the early stages, the total interest reduction will be more significant. This strategy can help borrowers reduce their overall cost burden. The Monte Carlo simulation provides insight into the impact of interest rate fluctuations on the total cost of a mortgage. In low interest rate conditions, borrowers can save up to 20% compared to high interest rate conditions. However, variable interest rates also pose risks, especially in unstable economic conditions. Therefore, it is important for borrowers to understand the dynamics of interest rates and choose a scheme that suits their risk tolerance. This simulation emphasizes the importance of careful planning before choosing a fixed or variable interest scheme. Linear optimization shows that early repayment, especially in the early years, has a significant impact on reducing total interest. For example, in the simulation scenario, early repayment of 10 million rupiah in the first period can reduce total interest by 10%. This strategy is very effective for borrowers who have the budget flexibility to make larger payments at the beginning of the loan period. This approach not only helps reduce interest expenses but also speeds up the debt repayment period.

5 Conclusion

The results of this study indicate that the application of mathematical models can provide an optimal strategy to reduce the total cost of Home Ownership Credit (KPR). Through a combination of annuity approaches, Monte Carlo simulations, and linear optimization, borrowers can gain in-depth insights into managing their mortgage payments. It is recommended that borrowers consider variable interest schemes carefully, given the potential for greater cost savings but with higher risks. In addition, financial institutions need to educate customers about the benefits of early repayment and how it can influence total cost to be paid.

Overall, this study concludes that the combination of these mathematical approaches is not only effective but can also provide a practical solution for borrowers to minimize mortgage costs. By implementing an optimal payment strategy, borrowers can improve their financial efficiency and reduce their debt burden in the long run. This study also provides guidance for financial institutions to educate their customers about the importance of a measurable payment strategy. The integration of this model is expected to encourage the adoption of a more optimal payment strategy by borrowers in Indonesia, as well as improve financial literacy related to mortgage management.

Reference

COMICS. (2017). Analysis of the application of the Analytic Hierarchy Process (AHP) and MOORA methods in the Home Ownership Credit payment strategy. *Journal of Applied Economics and Optimization, 4*(1), 55-67.

Hancock, D., & Humphrey, D. B. (1997). Payment transactions, instruments, and systems: A survey. *Journal of Banking &*

Finance, *21*(11-12), 1573-1624.

Kumar, A., Gupta, R., & Singh, T. (2015). *Mathematical Models in Financial Analysis*. Cambridge University Press, UK.

Mbillwe, S. K. (2006). Effects of interest rates on performance of Financial Institutions: a case study of Equity Bank Meru.

Nasution, C. (2021). Overview of Indonesian Law in the Purchase Transaction of Home Ownership Credit (KPR). *International Journal of Research and Review*, *8*(5), 286-291.

Wang, X, Li, H, & Zhang, Y. (2021). Risk Management of Variable Mortgage Rates Using Monte Carlo Simulation. *Journal of Financial Modeling*, *6*(2), 123-135.

Zhao, L., Chen, Q., & Hu, J. 2021). Integration of Annuity Models and Linear Optimization for Mortgage Payment Strategies. *International Journal of Housing Economics*, *8*(3), 78-92.