

Financial Mathematical Model for Optimizing MSME Cash Flow Using Annuities and Micro Payment Scheme Simulations

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ABSTRACT

MSMEs contribute significantly to the national GDP and employment, but they still face serious challenges in managing cash flow and accessing financing. Low financial literacy, particularly regarding the concept of annuities and financing schemes, often leads to unstable business liquidity. This study aims to develop an adaptive annuity-based financial mathematical model to help MSMEs plan cash flows, process microfinance schemes, and validate its effectiveness through a case study. The research methods include mathematical modeling, numerical analysis, spreadsheet/Python-based computational simulations, and verification on MSMEs in the food sector in Bandar Lampung. The simulation results indicate that business surplus can be used as a basis for installment financing with an annuity approach, both conventional and sharia. The case study on the "Bulek" Meatball MSME shows that with an average surplus of IDR 2,421,875 per month, the MSME is eligible to take out murabahah financing worth IDR 50,000,000 with a 15% margin for a 24-month term, because the fixed installment of IDR 2,395,833 is still within the business's surplus capacity. This research contributes to the development of applied financial mathematics theory, provides practical tools in the form of interactive simulations, and produces policy recommendations for microfinance institutions to be more adaptive to the cash flow patterns of MSMEs.

INTRODUCTION

Micro, Small, and Medium Enterprises (MSMEs) contribute significantly to Indonesia's economic development, both through increasing Gross Domestic Product (GDP), absorbing labor, and strengthening the local economy. This sector also plays an important role in promoting financial inclusion and reducing socioeconomic inequality. However, despite this strategic role, MSMEs still face serious challenges, particularly in cash flow management and limited access to appropriate financing schemes. Low financial literacy, especially understanding annuities, interest rates, and installment planning, often causes business owners to make impulsive financing decisions without careful calculation. This condition has implications for difficulties in maintaining liquidity and high risk of default.

LITERATURE REVIEW

In addition, financial institutions and microfinance generally offer generic schemes, which do not take into account the varying income patterns of MSMEs across different sectors. The mismatch between payment schedules and actual cash flows results in low financing effectiveness and reduces trust between MSMEs and financial institutions. Therefore, a data-driven scientific approach is needed to design financial models that are more adaptive to the dynamics of MSME cash flows. One relevant approach is the application of an annuity-based financial mathematical model, which can simulate fixed installment schemes or adjust to seasonal income. This research is important for developing financial models that can assist MSMEs in long-term cash flow planning while also serving as a practical decision-making tool for business actors and microfinance institutions.

METHODOLOGY

Research Location and Time

This research will be conducted in Bandar Lampung City, North Teluk Betung District, with case studies on MSMEs in the food, handicraft, or service sectors that are willing to cooperate. The computing and simulation processes will be carried out in the computer laboratory of the Faculty of Mathematics and Natural Sciences in accordance with the available facilities. The research will be conducted from July 2025 to December 2025.

Research Materials and Tools

The materials and tools used in this study included stationery, laptops, questionnaires for additional data (if necessary), spreadsheet/Python software, Zoom/Google Meet, and scientific calculators for manual annuity checks.

Research Procedures

This study uses a qualitative approach through mathematical modeling and numerical simulation. An annuity-based financial model was developed to reflect the cash flow of MSMEs, which was then analyzed through simulation scenarios using software. Validation was carried out through case studies of local MSMEs that were analyzed.

RESULT AND DISCUSSION

Annuity interest is a payment calculation system in which the total payment (installment) remains the same each month, but the proportion of interest and principal changes gradually. This calculation method is found in credit installments for mortgage financing, leasing, and long-term loans (Fiththohiro, 2021). This method differs from flat interest or effective interest, which offer fixed monthly payments, but with the composition of interest and principal changing over time.

Annuity payments can be made at the beginning of the period or at the end of the period. If payments are made at the end of each period, it is called a deferred annuity. Conversely, if payments are made at the beginning of each period, it is called an immediate annuity. In addition to the difference in the timing of receipt or payment, the two types of annuities are also distinguished by slight modifications to the formula, such as a regular annuity where the payment for each period is always the same, and an annuity with varying payments where the value of each period's payment is not the same. In the discussion of annuities, there are two important terms, namely present value, which is the value of all payments if the annuity is paid at once, and cumulative value, which is the total amount of all payments at a certain point in the future (Devni, 2014).

For annuity payments, we can calculate the present value and future value. The following are three variations of annuities based on the payment period (Adil, 2025) so that the instrument that best suits the characteristics of the loan and the financial capabilities of MSMEs can be selected.

1. Ordinary Annuity

An ordinary annuity is an annuity with payments made at the end of each period, whether monthly or annually (Wiyono, 2023). This annuity is widely used in mortgage products and conventional bank loans because it matches the pattern of customers' monthly salary payments. The following are the formulas for calculating the present value and future value of ordinary annuity payments (Adil, 2025).

$$PV = A \left[\frac{1-(1+i)^{-n}}{i} \right] \quad (1)$$

$$FV = A \left[\frac{(1+i)^n - 1}{i} \right] \quad (2)$$

Information:

PV = Present Value

FV = Future Value

A = Large payment per period

i = Interest rate per period

n = Number of periods

2. Annuity Due

An annuity due is an annuity with payments made at the beginning of each period (Mandailina, 2017). This annuity is often found in leasing or business lease financing. This mechanism benefits creditors because early payments reduce credit risk while allowing debtors to immediately use the

financed assets. The following are the formulas for calculating the present value and future value of annuity due payments (Adil, 2025).

$$PV = A \left[\frac{1 - (1+i)^{-n}}{i} \right] \cdot (1+i) \quad (3)$$

$$FV = A \left[\frac{(1+i)^n - 1}{i} \right] \cdot (1+i) \quad (4)$$

Information:

PV = Present Value

FV = Future Value

A = Large payment per period

i = Interest rate per period

n = Number of periods

3. Deferred Annuity

A deferred annuity is an annuity with periodic payments that are deferred for a certain period of time (Permana, 2016). This annuity differs from ordinary annuities and maturity annuities in terms of capital investment. This is because there is a grace period during which interest is not calculated. For example, the first payment may be deferred for several periods after the first interest payment period. The following are the formulas for calculating the present value and future value of deferred annuity payments (Adil, 2025).

$$PV = A \left[\frac{1 - (1+i)^{-n}}{i} \right] \cdot (1+i)^{-t} \quad (5)$$

$$FV = A \left[\frac{(1+i)^n - 1}{i} \right] \quad (6)$$

Information:

PV = Present Value

FV = Future Value

A = Large payment per period

I = Interest rate per period

n = Number of periods

Good cash flow management is crucial for MSMEs because stable liquidity allows them to carry out daily operations, overcome financial challenges, and take advantage of growth opportunities. In addition, smooth cash flow indicates that financial management is well-managed and capable of generating consistent income. MSMEs are in dire need of good cash management because many business owners do not understand or implement it in their businesses.

Cash flow management is central to the survival of MSMEs in both the short and long term (Amaliyah, 2024). Cash flow management in MSMEs consists of cash planning, cash monitoring, and cash control, as explained below.

1. Cash Flow Planning
2. Cash Flow Monitoring
3. Cash Flow Control

The role of banks and non-bank financial institutions is crucial as a means of collecting and channeling public funds more effectively and efficiently to improve people's lives. Banks and non-bank financial institutions are

financial intermediaries that play a very important supporting role in the economy (Rachmawati, 2022).

Operational activities in banking are divided into two categories: conventional banking, which still implements an interest-based system, and Islamic banking, whose entire operational activities are based on Islamic principles. The significant difference between conventional banks and Islamic banks can be seen in the implementation of the interest system. In conventional banks, interest rates are determined by fluctuations in bank interest rates, while Islamic banks have a profit-sharing system that has been agreed upon by the bank and its customers. Basically, Islamic and conventional banks have the same objective, which is to provide profits through loans for business capital, fund deposits, financing of people's business activities, or other transaction activities based on Islamic principles (Rachmawati, 2022).

Bank Syariah Indonesia (BSI) is one of the Islamic banks in Indonesia that is expected to contribute to national economic development by contributing to the welfare of the community. Bank Syariah Indonesia's flagship product is Microfinance for MSME players. Microfinance at BSI is productive financing in the form of working capital to meet the needs of the production process to improve business (Rachmawati, 2022).

In bank financing, there are financing elements such as contracts, grace periods, trust, risk, and compensation. Microfinance at BSI is focused on developing MSMEs. Microfinance at BSI is productive financing in the form of capital to meet production needs using murabahah contracts.

The murabahah scheme in Bank Syariah Indonesia's microfinance begins with customers applying for financing to obtain additional capital and completing the necessary financing documents for approval of the financing process. The bank then verifies and analyzes the application for financing approval. If the bank cannot make a direct purchase from the supplier, a wakalah agreement is used with the customer in accordance with the bank's representative, who purchases as an investment or capital for the supplier in accordance with the financing objective, followed by the disbursement of wakalah funds to the customer's account. The supplier then sends the assets purchased by the customer as the bank's representative, and the customer provides proof in the form of a receipt or proof of purchase from the supplier to the bank. After that, the customer pays installments to the bank in accordance with the installments agreed upon in the contract.

Based on the description of annuities and cash flows above, this study will discuss the cash flows of MSMEs using ordinary annuities. In ordinary annuity payments, this study will calculate the future value, which is an estimate of the current value of money in the future (Nurshalihah, 2022). The formula for future value in ordinary annuities is as follows.

$$FV = A \left[\frac{(1+i)^n - 1}{i} \right] \quad (2)$$

Information:

PV = Present Value

FV = Future Value

A = Large payment per period
 i = Interest rate per period
 n = Number of periods

Based on the results of surveys and interviews, the “Bulek” Meatball MSME only records income and expenses from their business. Financial data shows that the total income of the “Bulek” Meatball MSME from January 2025 to August 2025 was IDR 335,143,000.00, with an average of IDR 41,892,875.00 per month, while monthly expenses averaged IDR 39,471,000.00.

Based on these financial records, it was found that the average monthly surplus/profit of the “Bulek” Meatball MSME was IDR 2,421,875.00. Assuming that this profit is stable, a mathematical model will be created using the future value of a straight-line annuity. Mathematical simulations with periods of 12, 24, and 36 months at interest rates of 0.5% per month and 1% per month are presented in the following table.

Table 1. Mathematical Calculations using Future Value and Present Value for Ordinary Annuities

Interest rate (month)	Term (months)	Average profit/month C (Rp)	Future Value (FV) after n months (Rp)	Present Value (PV) – borrowing capacity (Rp)
0.5% (6%/month)	12	2421875	29875190	28139601
0.5% (6%/month)	24	2421875	61593017	54644442
0.5% (6%/month)	36	2421875	95267129	79609492
1.0% (12%/month)	12	2421875	30715437	27258391
1.0% (12%/month)	24	2421875	65326360	51448829
1.0% (12%/th)	36	2421875	104326815	72916614

Based on the table above, if MSMEs save for 12-36 months, their savings will grow, but the growth will be relative (IDR 29-104 million, depending on the tenor and interest rate chosen). This is useful for building emergency reserves or working capital for MSMEs. If MSMEs use their surplus/profits as installments for loans, present value provides an overview of the maximum financing (loan) that can be taken now if monthly installments are limited to that surplus. Example: at $i=1%$ and $n=24$, MSMEs can take out a loan of around IDR 51,000,000.00 with installments of IDR 2,420,000.00/month for 24 months.

Table 1 shows that the higher the interest rate (i), the lower the present value, meaning that MSMEs receive smaller loans with the same installments. Choosing a financing institution with a lower margin or a suitable tenor can increase financing. When MSMEs choose to extend the tenor by increasing the present value (meaning they get a larger loan), this results in an increase in the cumulative total payment, so that the total cost also increases. Therefore, the choice of a tenor that balances current funding needs and future payment burdens needs to be carefully considered.

Financing through Islamic banks, in this case BSI, is explained as having no interest but using contracts that are valid according to Sharia law so that banks earn profits through margins (sales profits) or profit sharing. In this Sharia practice, fixed monthly installment payments, as calculated in the annuity above, are still used but with a different form of contract (agreement).

Based on the annuity calculation above, MSMEs use their monthly surplus as fixed installments for microloans, so the system used in sharia financing is murabahah (sale and purchase with margin). The following is a murabahah model with fixed installments:

The total amount to be paid by the debtor (MSME) is:

$$S = P_0 (1+r_m)$$

with P_0 : capital requirements for MSMEs

r_m : margin.

In this murabahah practice, monthly installment payments are agreed upon by both parties, with the mathematical model as follows:

$$A = \frac{S}{n} = \frac{P_0 (1+r_m)}{n}$$

where A = fixed monthly installment and n = number of payment periods. Based on the financial condition of the MSME, a decision will be made that the MSME requires capital. $P_0 = \text{Rp}50.000.000,00$. The financing scheme agreed upon by BSI and MSMEs is murabahah with a margin = $r_m = 15\%$ and a 24-month term.

The total amount of payments to be made by MSMEs will be calculated.

$$S = P_0 (1+r_m) = \text{Rp}50.000.000,00 \times (1 + 0,15) = \text{Rp}57.500.000,00$$

With a 24-month term, the monthly annuity (installment) will be calculated as follows:

$$A = \frac{S}{n} = \frac{\text{Rp}57.500.000,00}{24} = \text{Rp}2.395.833,33$$

The monthly surplus/profit of the "Bulek" MSME is referred to as C , $\text{Rp}2,421,875.00$, so that $C - A \approx \text{Rp}2,421,875.00 - \text{Rp}2,395,833.33 \approx \text{Rp}26,041.67$. The result of $C - A$ shows that the MSME is eligible to apply for the financing scheme at BSI.

CONCLUSIONS AND RECOMMENDATIONS

The adaptive annuity model for the cash flow conditions of the "Bulek" Meatball MSME is a regular annuity that calculates the present value, namely $A = \frac{S}{n} = \frac{P_0 (1+r_m)}{n}$. A microfinance scheme simulation that can be implemented is the murabahah method with margins. = $r_m = 15\%$ and a 24-month tenor, resulting in monthly installments of $\text{Rp}2,395,833.33$, so that the effectiveness of this annuity model can be applied to the "Bulek" Meatball MSME with a measurable difference between profits and installments.

FURTHER STUDY

This research still has limitations, so further research is still needed.

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REFERENCES

- Adil, N. R., et al. (2025). Analisis anuitas biasa dan anuitas jatuh tempo pada kredit motor jenis sporty/fashion dengan menggunakan metode bunga flat dan efektif. *Anggaran: Jurnal Publikasi Ekonomi dan Akuntansi*, 3(3), 1-17.
- Alhazami, L., Judijanto, L., Harto, B., Sulistianingsih, S., Utami, A. T., Rustam, H. A., & Meta, W. (2024). *Manajemen keuangan: Praktik bagi wirausaha pemula*. PT Sonpedia Publishing Indonesia.
- Amaliyah, F., Yasmin, A., & Hetika. (2024, October). Analisis pengelolaan kas pada UMKM. *Owner: Riset & Jurnal Akuntansi*, 8(4).
- Astuty, D. A., Maharani, P. N., Triany, M., Pratama, A. A., Amanda, C. A., Tarigan, H. S., & Azri, N. I. (2024). Upaya inovatif peningkatan ekonomi lokal melalui optimalisasi UMKM opak di Desa Paya Bengkuang. *Jurnal Pengabdian kepada Masyarakat Nusantara*, 6(1), 1366-1373.
- Fiththohiro, I., & Sam, M. (2021). Program anuitas bagi nasabah bank perkreditan rakyat di Kota Palopo. *Infinity: Jurnal Matematika dan Aplikasinya*, 1(2), 12-21.
- Harahap, L. M., Aulia, D., Tambunan, I. P., Nurbani, K., & Hutapea, M. N. (2025). Pengaruh peran UMKM dalam kebijakan penanggulangan kemiskinan dan pengangguran. *Jurnal Ilmu Manajemen, Bisnis dan Ekonomi (JIMBE)*, 3(1), 70-77.
- Mandailina, V. (2017). Peningkatan kemampuan perhitungan matematika anuitas masyarakat Desa AI Bukaq Lombok Tengah. *JMM (Jurnal Masyarakat Mandiri)*, 1(1), 68-71.
- Nurshalihah, N. D., et al. (2022). Analisis konsep time value of money dalam perspektif ekonomi Islam. *Jurnal Pendidikan dan Konseling*, 4(6), 4815-4823.
- Nusantara, P. A. N. P. (2024). Analisis penerapan standar akuntansi keuangan EMKM pada usaha mikro kecil dan menengah di Kab. Konawe Sulawesi Tenggara (Studi kasus UMKM Toko Sembako Rahmah) [Doctoral dissertation, Universitas Islam Indonesia].
- Pane, A. S. A. S., Putri, H. R., Purba, A. T., & Harahap, L. M. (2025). Peran usaha mikro kecil menengah (UMKM) terhadap perekonomian Indonesia. *Jurnal Penelitian Ilmiah Multidisipliner*, 1(2), 122-129.
- Permana, B. N., Purnamasari, Y., & Purnamasari, I. (2016). Penerapan metode projected unit credit dan entry age normal pada asuransi dana pensiun (Studi kasus: PT Inhutani I Cabang Kabupaten Berau). *Ekspansional*, 7(2), 171-178.
- Rachmawati, D. W., & Yasin, A. (2022). Pengaruh pembiayaan mikro terhadap perkembangan UMKM nasabah BSI KCP Mojopahit 2. *Jurnal Ekonomika dan Bisnis Islam*, 5(2), 145-156.
- Rahmawati, D., Apriady, M. N., & Wisudanto, W. (2024). Crowdfunding sebagai alternatif pembiayaan usaha mikro kecil dan menengah (UMKM) akibat meningkatnya jumlah pelaku UMKM di Indonesia. *Sebatik*, 28(1), 33-40.
- Wiyono, Wijaya, A. H., & Culadi, R. D. (2023). Analisis perhitungan tabungan hari tua berbasis android. *Akselerator: Jurnal Sains Terapan dan Teknologi*, 4(2), 12-18.
- Zahari, Y. K., Hidayah, K., Juansa, A., Aisa, N. N. M., Hafni, D. A., Nurkholik, A., ... & Rintasari, N. (2025). *Manajemen keuangan UMKM: Konsep dan penerapannya pada UMKM era digital*. Henry Bennett Nelson.