Calculation of Loan Amount When Cooperatives Do Not Make Profits with Non-Linear Equation Method Using Secant and Its Implementation with MATLAB

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Abstrak

Keuntungan koperasi memiliki dampak yang signifikan terhadap jumlah pinjaman yang dimilikinya. Oleh karena itu, penting untuk melakukan perhitungan jumlah pinjaman minimum guna menjaga nilai keuntungan koperasi. Penelitian ini menerapkan metode iterasi persamaan non-linear menggunakan metode Secant, yang sesuai untuk kasus-kasus dekat dengan titik puncak grafik yang tidak dapat dihitung dengan Metode Newton-Raphson. Penelitian ini mengatur batas iterasi sebelumnya untuk mengendalikan jumlah iterasi yang dilakukan, meningkatkan efisiensi perhitungan secara keseluruhan. Implementasi metode Secant dilakukan dengan menggunakan perangkat lunak MATLAB, yang memungkinkan analisis dan evaluasi yang akurat terhadap kondisi keuangan koperasi. Diharapkan bahwa hasil penelitian ini akan memberikan panduan praktis dalam manajemen keuangan koperasi, dengan fokus pada menjaga stabilitas keuntungan serta pertumbuhan pinjaman. Dengan demikian, penelitian ini tidak hanya memberikan kontribusi teoritis terhadap bidang persamaan non-linear, tetapi juga aplikatif dalam konteks pengelolaan koperasi secara praktis. Melalui pendekatan ini, kajian ini diharapkan dapat memberikan pemahaman yang lebih dalam tentang bagaimana koperasi dapat memanfaatkan metode numerik untuk mengoptimalkan kebijakan pinjaman mereka, menghindari kerugian, dan menjaga kelangsungan usaha secara finansial. Hasil penelitian ini dapat memberikan landasan bagi peneliti dan praktisi untuk mengembangkan strategi yang lebih efektif dalam manajemen koperasi, memperkuat peran mereka dalam mendukung perekonomian lokal dan memberdayakan anggotanya secara berkelanjutan.

Kata kunci: non – linear_1, metode secant_2 matlab implementasi_3.

Abstract

The profitability of cooperatives significantly impacts the amount of loans they possess. Therefore, it is crucial to calculate the minimum loan amount to maintain cooperative profitability. This study applies the iterative method of nonlinear equations using the Secant method, suitable for cases near the peak of graphs that cannot be computed using the Newton-Raphson method. The research sets a predefined iteration limit to control the number of iterations, enhancing overall calculation efficiency. The Secant method is implemented using MATLAB software, enabling precise analysis and evaluation of cooperative financial conditions. The research aims to provide practical guidance in cooperative financial management, focusing on maintaining profitability and loan growth. Thus, the study contributes not only theoretically to the field of nonlinear equations but also practically to cooperative management. Through this approach, the study seeks to deepen understanding of how cooperatives can utilize numerical methods to optimize their loan policies, avoid losses, and sustain financial viability. The findings serve as a foundation for researchers and practitioners to develop more effective strategies in cooperative management, strengthening their role in supporting the local economy and empowering members sustainable.

Keywords: *non-linear equations; Secant method; MATLAB implementation.*

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1. INTRODUCTION

Cooperatives, as one of the foundational pillars of the national economy, hold a strategic role in enhancing the economic welfare of their members through various community-based financial activities, particularly in the field of savings and loans (Nasution et al., 2024). Their existence is not only a reflection of economic democracy but also a manifestation of the mutual cooperation spirit that is deeply rooted in Indonesian culture. Through savings and loan services, cooperatives enable members—many of whom are micro, small, and medium-sized entrepreneurs or individuals with limited access to banking—to obtain financing with more flexible and affordable terms compared to those offered by conventional financial institutions (Maulinda et al., 2024). These advantages make cooperatives a crucial support system for financial inclusion and grassroots economic empowerment. However, in practice, maintaining the financial stability of cooperatives is a continuous challenge. Various external and internal factors—such as high operational costs, weak financial management, increased rates of non-performing loans, and declining loan interest income—can lead to conditions in which cooperatives fail to generate expected profits (Tambunan, 2021).

In situations where cooperatives are unable to generate profit, careful financial planning becomes critical to ensure sustainability. One of the key aspects that must be addressed is the cooperative's ability to continue offering loans, since loan services are often the primary source of operational income and also serve as the backbone of cooperative-member interaction (Arsyad et al., 2022). In such conditions, it is essential to determine the optimal or minimum loan amount that still allows the cooperative to operate without incurring further financial loss. This involves the estimation of a critical point in the loan distribution where revenues are just sufficient to cover operational expenses—despite the absence of net profit (Ratih et al., 2022). The difficulty in determining this lies in the complex, interdependent nature of the variables involved: interest rates, fixed and variable operational costs, total number of active loan recipients, and the remaining balance of outstanding loans (Rochaety & Tresnati, 2022). These variables interact in non-linear ways, which makes it nearly impossible to obtain exact solutions using conventional analytical methods. Instead, the problem must be translated into a non-linear equation that represents the cooperative’s financial condition under zero-profit assumptions—an equation that must then be solved using numerical methods due to its non-analytical nature (Yahya, 2009).

Numerical methods offer a powerful alternative for solving such non-linear equations, especially within the realm of financial optimization for cooperatives and similar institutions (Mukaromah & Atsani, 2024). Among the various numerical techniques available, the Secant method stands out as a practical and efficient approach. It is an iterative algorithm that uses two initial estimates to approximate the root of a function and does not require the derivative of the function to be calculated, as opposed to the Newton-Raphson method (Sujaya et al., 2024). This absence of derivative calculation is particularly advantageous in cases where the function is difficult to differentiate or does not have a clear analytical form. Furthermore, the Secant method is known for its relatively low sensitivity to the choice of initial values under certain mathematical conditions, which enhances its robustness when applied to financial models that are influenced by unpredictable real-world factors (Hardianto et al., 2022). Given these advantages, the Secant method is highly suitable for financial modeling of cooperatives, where the underlying equations often exhibit non-linear characteristics and are derived from complex interactions among economic parameters.

This study employs the Secant method to compute the appropriate loan amount under zero-profit conditions and implements the algorithm using MATLAB, a widely used platform for numerical computation and modeling. MATLAB was chosen due to its powerful computational capabilities, ease of handling numerical iterations, and ability to visualize the behavior of functions and convergence patterns during the iterative process. The algorithm’s implementation includes key parameters such as initial guesses, error tolerance, and a maximum iteration limit, all of which are carefully defined to ensure convergence, minimize computation time, and maintain solution accuracy. The incorporation of these parameters also reflects real-world constraints that may arise in the management of cooperative financial systems.

Based on the recurring problems observed in the operations of savings and loan cooperatives, the research proposes the following formulation: How can the total loan amount be calculated when the cooperative is not generating profit using the Secant method, and how can this be implemented efficiently using MATLAB? In response to this problem, the objectives of the research are outlined as follows: (1) To apply the Secant numerical method in solving a non-linear equation that models the cooperative's financial condition during a zero-profit phase; (2) To design and implement a computational algorithm using MATLAB for determining the optimal loan threshold that the cooperative can safely issue without triggering financial losses; and (3) To offer both practical and theoretical solutions that can assist cooperative stakeholders in managing financial crises and making more data-driven and rational decisions in times of economic difficulty. Ultimately, the study aims to contribute to the ongoing discourse on strengthening cooperative resilience and improving financial sustainability strategies in community-based financial systems.

2. METHOD

This research is a quantitative research that is applicable, with a numerical-computational approach to solve cooperative financial problems formulated in the form of non-linear equations. The purpose of this study is to develop a model for calculating the amount of loans in the condition of cooperatives not making profits using the Secant iterative method, as well as to implement the model in the MATLAB program. The data used in this case uses non-linear equations as below:

$$f(x) = x + e\text{-}x \cos(x) - 1.3 \quad (1)$$

In the equation, $f(x) = y$ which is the initial of profit and x is the variable of the loan. Meanwhile, the cooperative profit graph is shown in figure 1.

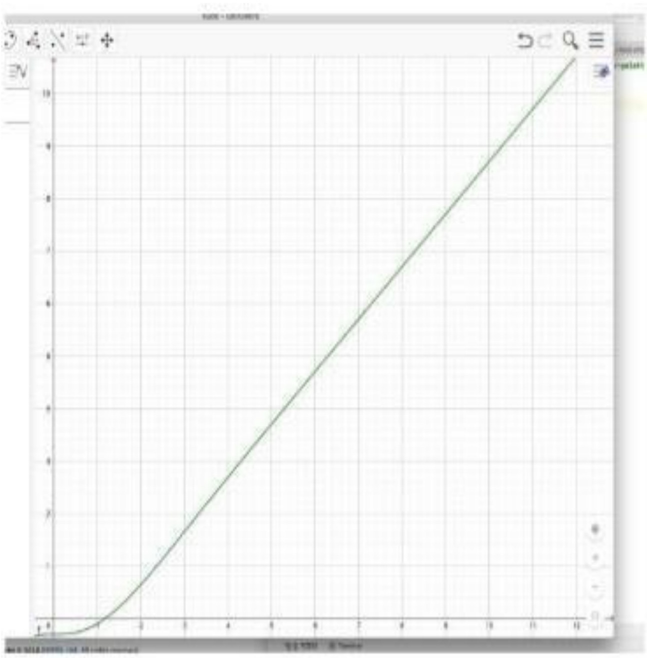

Figure 1. Cooperative Profit Chart

He explained, the x-axis of the graph shows the total loans in the cooperative while the y-axis in the cooperative is used to show the total profits obtained by the cooperative.

3. RESULTS AND DISCUSSION

3.1 Calculation Results

x = 1.1849

So, cooperatives with graphs like the ones in the research data must have a loan value of more than
x * IDR 10,000,000,-i.e. approximately must exceed IDR 11,849,000,- .

3.2 Hasil Perhitungan Program

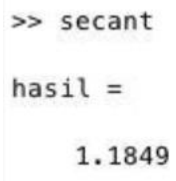

Figure 2. Program Calculation Results

The image shown is the output of a MATLAB program that runs the Secant method algorithm to find the root of a non-linear equation. On the first line is the command "secant", which indicates that the user is running a MATLAB function or script named "secant.m".

This means that the result of the iteration process of the Secant method is a value close to the root of the function, i.e. . This value is obtained by meeting the error tolerance criteria that have been defined in the script (usually very small, such as). In other words, the number 1.1849 is the root of the numerical approach of the functions that have been incorporated into the Secant method. This result indicates that when the value is close, the value of the function is very close to zero, so it can be considered a solution of the equation$f(x) = 0x \approx 1.184910^{-6}x1.1849f(x)$.

3.3 Program Workflow (Flowchart)

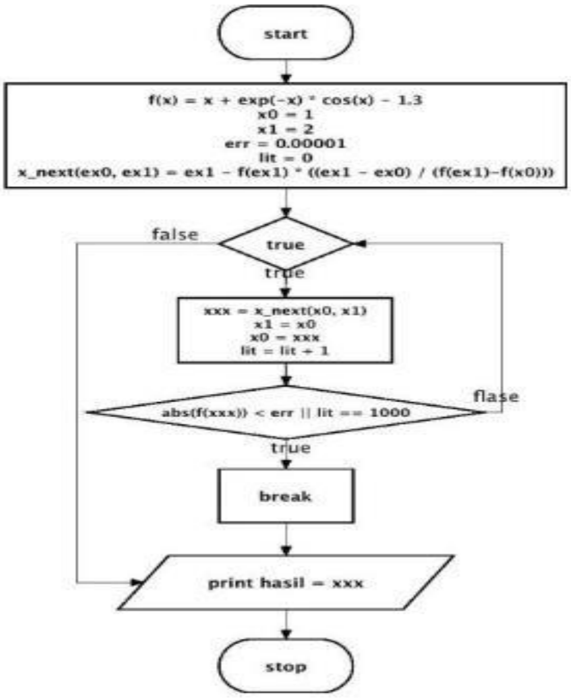

Figure 3. Flowchart Program

The flowchart in Figure 3 shows a representation of the workflow of the Secant numerical method to solve a non-linear equation problem, in this case the algorithm starts by defining the root to be searched, assigning the two initial values of the guess and , and determining the error tolerance limit and the maximum iteration limit. At each iteration step, the Secant method is used to calculate the root value of the next approach using the formula:$f(x) = x + \exp(-x) \,.\, \cos(x) -$

1.3. $(x_0 = 1 x_1 = 2)(\varepsilon = 0.000001)$

$$x_{next} = x_1 - \frac{f(x_1)(x_1 - x_0)}{f(x_1) - f(x_0)}$$

The guessing values, which serve as the initial approximations for the root, are continuously updated during each iteration based on the results of the previous calculations. This iterative process is carried out repeatedly under the condition that the absolute value of the function evaluated at the current approximation remains greater than the specified error tolerance, or that the number of iterations performed has not yet reached a maximum limit, which in this study is set at 1000 iterations. These two stopping criteria—error tolerance and maximum iteration count—are essential to ensure that the algorithm does not enter an infinite loop and that the solution produced is both computationally efficient and numerically reliable. As the iteration progresses, the algorithm checks after each step whether either of these conditions has been violated. If the function value becomes sufficiently close to zero, indicating that a root has been found within the acceptable level of accuracy, or if the process has already run for 1000 iterations without achieving convergence, the loop will terminate automatically. At this point, the last computed value, which represents the closest estimate to the actual solution of the equation f(x)=0f(x) = 0, is returned and displayed as the output.

This mechanism, as illustrated in the accompanying flowchart, highlights how the Secant method functions effectively as a root-finding algorithm for non-linear equations. One of the main advantages of the Secant method lies in its ability to approximate the root without requiring the computation of the derivative of the function, which can be difficult or impossible to obtain analytically in many real-world problems. Unlike the Newton-Raphson method that depends heavily on the availability and correctness of the derivative, the Secant method relies solely on function evaluations and prior approximations, making it more adaptable to a wider range of mathematical problems. Furthermore, the integration of iteration limits and error thresholds allows the process to be tightly controlled and monitored, ensuring that the method does not produce unstable or divergent results. This balance between efficiency, flexibility, and control makes the Secant method a powerful tool in numerical analysis, particularly for solving equations that model complex financial systems, physical phenomena, or engineering scenarios where analytical solutions are not feasible.

4. CONCLUSION

The program begins by declaring the mathematical equation to be solved, along with the necessary formulas and the initial guess values, typically denoted as x0x_0 and x1x_1. These initial values are crucial, as they serve as the starting point for the iterative process using the Secant method. In this stage, other supporting variables are also defined, such as the maximum number of iterations allowed and the acceptable error tolerance value, which is used as a stopping criterion. Once the initial setup is completed, the program proceeds to initialize the loop structure that performs the Secant iterations. The core of the algorithm lies in a x_0 loop, which continues to execute as long as certain logical conditions remain true. Specifically, the loop runs while the absolute value of the function at the current approximation is still greater than the predefined error tolerance, and the number of iterations has not exceeded the maximum limit—commonly set to 1000 to prevent infinite loops or excessive computation. During each iteration, the program calculates the next approximation of the root based on the Secant formula, which uses the previous two values to estimate the slope of the secant line and compute the next intersection point with the x-axis. This process continues iteratively, updating the values of x0x_0 and x1x_1 each time, moving them closer to the actual root of the function. The goal is to find an x-value that makes f(x)≈0f(x) \approx 0 within the specified tolerance range. Once either the function value is sufficiently close to zero or the maximum iteration count is reached, the loop terminates. The final approximated root is then displayed as the output. This structured and controlled approach ensures both efficiency and accuracy in solving non-linear equations using numerical methods.

REFERENCE

Abadi, Rizki. (2016). Koperasi apa saja yang mesti anda ketahui? Diakses dari https://www.cermati.com/artikel/koperasi-simpan-pinjam-apa-saja-yang-mesti-anda-ketahui pada tanggal 30 Januari 2018.

Arsyad, U. R., Supatminingsih, T., & Hasan, M. (2022). Analisis Penilaian Tingkat Kesehatan Koperasi Simpan Pinjam Di Kota Makassar Ditinjau Dari Non Performing Loan (Npl) Pada Tahun 2020-2021: Studi Kasus Pada Koperasi Simpan Pinjam Berkat Bulukumba Cabang Antang. Jurnal Ekonomi, Sosial & Humaniora, 4(03), 102-116.

Hardianto, F., Wicaksono, L. A., & Nurtjahjaningtyas, I. (2022). Perbandingan Kebutuhan Material Diaphragm Wall dan Secant Pile pada Proyek Grand Dharmahusada Lagoon Surabaya. Jurnal Rekayasa Sipil dan Lingkungan, 5(1), 90-98.

Maulida, D. R. W., Triyas, A. P. A., & Putri, H. L. (2024). Dinamika Keterlekatan Ekonomi: Hubungan UMKM dengan Koperasi Simpan Pinjam dalam Meningkatkan Pertumbuhan Usaha. Arus Jurnal Sosial dan Humaniora, 4(1), 322-329.

Mukaromah, I. A., & Atsani, M. R. (2024). PENERAPAN METODE BISECTION DAN NEWTON-RAPHSON UNTUK PENYELESAIAN AKAR PERSAMAAN NON-LINIER MENGGUNAKAN MATLAB. Jurnal Teknik Informatika dan Sistem Informasi (JURTISI), 4(2), 70-74.

Nasution, S., Hidayati, S., Nasution, P. R., & Hasyim, H. (2024). Peranan koperasi dalam perekonomian Indonesia. As-Syirkah: Islamic Economic & Financial Journal, 3(2), 522-530.

Pratiwi, Friska. (2013). Penyelesaian Persamaan Non Linier Dengan Metode Numerik. Diakses dari http://frizcup.blogspot.co.id/2013/04/penyelesaian-persamaan-non-linear.html pada tanggal 18 Februari 2018.

Ratih, N. R., Oktaviana, D., & Kusumaningarti, M. (2022). Kinerja keuangan koperasi sebelum dan saat pandemi Covid-19 terhadap sisa hasil usaha. JAS (Jurnal Akuntansi Syariah), 6(2), 184-197.

Rochaety, E., & Tresnati, R. (2022). Kamus Istilah Ekonomi (Edisi Kedua). Bumi Aksara.

Sujaya, K. A., Prayitno, S., Kurniati, N., & Sridana, N. (2024). Efektivitas metode Brent dalam penyelesaian masalah Break Even Point menggunakan pemrograman Pascal. Mandalika Mathematics and Educations Journal, 6(1), 120-130.

Tambunan, T. T. (2021). UMKM di Indonesia: perkembangan, kendala, dan tantangan. Prenada Media.

Yahya, C. S. (2009). Perbandingan metode Newton Raphson dengan metode Halley dalam menyelesaikan akar-akar persamaan non-linier (Doctoral dissertation, Universitas Islam Negeri Maulana Malik Ibrahim).