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Financial Aid of Higher Education in Malaysia: A Study Loan Case

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Abstract
The increment of financial expenses to study at higher education may concern all students and their parents. Not all parents are able to save enough money to bear the financial cost and thus making them apply for a study loan. Therefore, many private and government institutions offer an attractive loan to overcome this problem. Most of the finance institutions apply ordinary annuity method to calculate the installment and interest rate of the study loan. However, the mathematical model involved is a non-linear equation that causes the difficulty in calculating the interest rate. Thus, the main objective of this study is to solve a problematic situation to find the interest rate of a study loan based on Newton-Raphson method. By a scenario case, this method is found be a practical method, faster, more reliable, and produces accurate result in estimating the unknown interest rate. The method demonstrated in this study could provide a guideline for students or clients who need financial aid to higher education to find out the comprehensive and affordable interest rate. Hence, the clients or students could choose the best rate before proceeding the agreement of the loan for their further repayment in study loan.
Keywords: Study Loan, Annuity, Interest Rate, Higher Education, Newton-Raphson Method

Introduction

Affording financial expenses to study at university may concern all students and their parents. There are fees to pay for the courses and the need for finance of cost-of-living expenses. Therefore, some students take up part-time employment while some work during holiday term time as well as vacations to pay for the cost. Government and support agencies offer a variety of ways with scholarship and bursaries to help student accommodate the cost. There are financial institutions in Malaysia such as Jabatan Perkhidmatan Awam (JPA), Yayasan Negeri, Bank Negara and Khazanah. In this case the institutions will loan students a specific amount of money based on their field of study. Students will receive the amount of money at the beginning until the end of study. Repayment of the loan will start when the graduate starts working. The financial charge is calculated with the same manner as other forms of

borrowing or renting in which a loan will gain interest.

Usually, students are not concerned about the interest rate on a loan application. This issue is crucial because they can decide which institution loan is better for them to choose a lower interest rate. Moreover, interest rate of the study loan in the form of annuity is very difficult to find since annuity uses a non-linear equation formulation. Therefore, a numerical method is required to solve the interest rate.

The repayment of loan is usually in the form of annuity. Most of the finance institutions apply ordinary annuity method to calculate the installment and interest rate of the study loan. However, the mathematical model involved is a non-linear equation that causes the difficulty in calculating the interest rate. To compute the interest rate in this research, Newton-Raphson method or Newton method is used in which it is a practical technique for solving equations numerically. Rather than differential calculus, it is based on the simple idea of linear approximation.

The main objective of this study is as below:

- To solve a problematic situation to find the interest rate of a study loan based on Newton-Raphson method.

Literature Review

Study Loan

Most people understand that education is one of the most important ways to improve one's life prospects, to move from lower to higher income and wealth levels. However, higher education is often troubled by challenges such as decreased government financial assistance, higher tuition fee and increased student debt loads. Baradi and Malla (2017) states that education is significant as a source of input for economic, political, and social development, as well as a source of knowledge. Those with bachelor or diploma degrees earned more salary than those without one. The advantage of study loan is to provide deserving students with the opportunity to pursue education with financial assistance on reasonable terms and conditions.

In Malaysia, students rely on various funding options to pursue their studies in higher education institutes, which are typically provided by financial institutions in the form of loans or scholarships. Maybank, for example, awarded RM27 million in scholarships to students in 2018. CIMB Bank has disbursed RM10.6 million to 16 scholars to pursue undergraduate studies at reputable study institutions around the world as of December 2018. According to Petronas' 2018 Sustainability Report, more than 36,000 students worldwide received funding from the PETRONAS Education Sponsorship Programme (PESP), of which 387 students were awarded sponsorships in 2018, with 45 percent attending international universities and 55 percent attending Malaysian universities (Zakaria et al., 2020). A student loan is a critical financing tool for people, particularly students, who want to pursue higher education (Bertola and Hochguertel, 2007). Higher education costs, which rise year after year, are often out of reach for people with low or limited incomes.

It is critical to understand who chooses not to take out loans because these students have a significant advantage both during and after their studies. This could have long-term consequences for social mobility, especially if those who do not borrow are already from privileged backgrounds. Student loans, for example, are positively associated with dropout and negatively associated with graduation (Baker et al., 2017). Beyond academic success, those who do not take out student loans benefit from post-graduation outcomes as well. The looming debt creates a massive financial divide between debtors and non-debtors.

Furthermore, as research on the long-term consequences of student loan debt demonstrates, having student loan debt can limit or constrain graduates' decisions and choices regarding employment and careers, postgraduate studies, home ownership, family formation, health, retirement savings, and financial well-being (Gayardon et al., 2018).

Many studies have shown that financial concerns and debt can put pressure on individuals, compounding existing pressures on students and raising concerns about how student debt affects students' stress levels. Inadequate funds result in high living costs for borrowers who do not have enough money to cover the costs. Borrowers must then forego repayment for two, three, or more times. A late payment is also considered delinquent, as is a repayment that has not been made (Redd, 2001). Student's debt and other related economic problems are among the biggest sources of stress, according to a recent nationwide survey. Finance is the second most common source of stress among university students. More than one-third of those polled said their financial situation was painful or difficult to manage (Vaicondam and Wen, 2020). Furthermore, the majority of students who did not complete their studies were discovered to be in default on their study loan repayment (Woo, 2002).

Students' financial stress is measured through self-report, in which they consider the amount of debt that causes them to reduce their classroom burden, consider dropping out of school, or ignore their studies. Students who reported financial stress had lower scores, and their quarterly credits were reduced. Joo et al. (2008) also discussed in terms of academic influence and financial pressure on college students. Students who have had their studies interrupted, such as due to financial problems and the reduction of the burden of course or school students, have a greater personal financial pressure. Fear of debt is directly associated to student stress, indicating that students who are more fearful of debt have experienced more stress. No significant relationship was seen between perceived stress and estimated or federal student loans. The study also discovered that students who scored higher on debt thinking and understanding which had lower estimations of student loans, federal loans, and study loans. Furthermore, students with better loan thinking and understanding ratings were able to repay their loans in a shorter period of time than those with lower scores (Park et al., 2015).

For the following subsection, the compound interest, annuity and Newton-Raphson method were discussed for interest rate calculation in study loan.

Compound Interest

Compound interest in a bank savings account, loan, or investment grows exponentially rather than linearly over time. The compound interest is calculated on a loan or deposit based on both the initial principal and the accumulated interest from previous periods.

Generally, compound interest benefits investors and depositors. For example, banks benefit from compound interest when they lend money and reinvest the interest received in making profit. On the other hand, depositors who save in savings account received interest or dividend also benefit from compound interest.

Annuity

Annuity is a set of payments made in equal intervals of time. Ordinary annuity and annuity due are the two basic types of annuity. The regular payments of an ordinary annuity are made at the end of each period. For instance, bonds typically pay interest at the end of every six months. In contrast, regular payments of an annuity due are made at the beginning of each period. For example, rent paid to landlords typically are made at the beginning of each month.

The future value of an annuity is the value of a series of payments at a future date at a specified interest rate. The present value of an annuity is the current value of a series of payments based on a specified interest rate.

Newton-Raphson Method

The Newton-Raphson algorithm is practical algorithm because of its quick convergence yet given a certain accuracy level (Nagares et al., 2019; Ypma, 1995). This method is very conventional for its fast rate convergence and improving the convergence quality. Finding a root is one of the problems in many practical applications. In order to compare the performance, it is therefore very important to observe the cost and speed of the convergence. Akram and Ann (2015) conducted a study that complex equation systems with high-speed processing control are in need nowadays.

In this study, the interest rate of the study loan which is in the form of non-linear equation will be solved by Newton-Raphson method as it provides good and accurate results with fast convergence speed.

Methodology

There are numerous methods for calculating annuity interest rates especially in financial applications. However, this study aims to focus on solving the interest rate of study loan based on Newton-Raphson method. This method is selected due to its properties that requires fewer iterations to achieve convergence and this method is found much faster, more reliable, and produces accurate results (Nagares et al., 2019). In this study, a mathematical model of ordinary annuity to find interest rate of study loan is shown in Equation (1).

$$P = \frac{R}{i}[1 - (1 + i)^{-k}] \tag{1}$$

where ;
P = Principal value of study loan
R = Monthly repayment
i = Interest rate
k = number of repayments for the loan period

There are three main elements in ordinary annuity formulation. First, principal value of study loan. The principal of the loan relates to the present value of a loan. The larger the value of the principal of the loan, the larger the monthly repayment of the loan is. Second element is interest rates. The larger the interest rate, the larger the monthly repayment. Third element is number of repayments for the loan period. The longer of the loan repayment period, the higher amount of the monthly repayment. The number of repayments is generally expressed in months.

Equation (1) is transformed to Equation (2) and (3).

$$\frac{Pi}{R} = [1 - (1 + i)^{-k}] \tag{2}$$

$$\frac{Pi}{R} - [1 - (1 + i)^{-k}] = 0 \tag{3}$$

To employ Newton-Raphson method in ordinary annuity model, let $i = x$ and substitute x into Equation (3) to obtain Equation (4).

$$\frac{Px}{R} - [1 - (1 + x)^{-k}] = 0 \quad (4)$$

Newton-Raphson method also involves derivative of the function. Let $f(x)$ as the Equation (5) and the derivative of $f'(x)$ as the Equation (6) respectively.

$$f(x) = \frac{Px}{R} - [1 - (1 + x)^{-k}] \quad (5)$$

$$f'(x) = \frac{P}{R} - k(1 + x)^{-k-1}] \quad (6)$$

The iterative algorithm of Newton-Raphson method is given in Equation (7), where n is the number of iterations, $n = 0, 1, 2, \ldots$.

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)} \quad (7)$$

The Equation (7) is the general form of the most frequently used technique for solving non-linear algebraic equations using Newton-Raphson method (Akram and Ann, 2015).

To estimate the interest rate of ordinary annuity using Newton-Raphson method, the initial value (x_0) of the rate is considered small. The initial value in this study is taken as 1%, which is $x_0 = 0.01$. The algorithm for calculating the interest rate using Newton-Raphson method is shown in Table 1.

Table 1
Algorithm for Calculating the Interest Rate for Study Loan

No	Steps
1.	Obtain the input data ($R, P\ and\ k$)
2.	Calculate $f(x)$ using Equation (5)
3.	Calculate $f'(x)$ using Equation (6)
4.	Calculate interest rate using Equation (7) with the initial value
5.	Repeat iteration until the value of interest converges with the error $\lvert x_n - x_{n-1} \rvert$ close to zero.

A scenario study based on study loan case was presented in the following section.

A Scenario Case on Computation of Interest Rate for Study Loan

A scenario study is presented here: There is a study loan of RM 40,000 that had been agreed with 60 monthly instalments of RM800 per month in advance. The monthly repayment is to be made at the end of each month. Therefore, the monthly repayments are in the form of

Ordinary Annuity. Suppose the interest rate is unknown. In this study, Newton-Raphson method is used to estimate the interest rate.

Based on the scenario, the following input information is obtained: $P =$ RM40000, $k = 60$, $R =$ RM800.

Substituting the input data of the scenario study into the Equation (1), we obtain

$$40000 = \frac{800}{i}[1 - (1+i)^{-60}] \tag{8}$$

It is found that this is a non-linear equation. In order to use Newton-Raphson method to solve the interest rate, we let $x = i$. Using the input data of the scenario in the Equation (5), we get

$$f(x) = \frac{40000x}{800} - 1 + (1+x)^{-60} \tag{9}$$

Next, we get the first order derivative for $f(x)$ from Equation (6)

$$f'(x) = \frac{40000}{800} - 60(1+x)^{-61} \tag{10}$$

Substituting the $f(x)$ and $f'(x)$ into the Newton-Raphson method formulation as shown in Equation (7), we get

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$$

$$x_{n+1} = x_n - \frac{\frac{40000x_n}{800} - 1 + (1+x_n)^{-60}}{\frac{40000}{800} - 60(1+x_n)^{-61}}$$

$$x_{n+1} = x_n - \frac{50x_n - 1 + (1+x_n)^{-60}}{50 - 60(1+x_n)^{-61}} \tag{11}$$

Using initial value of $x_0 = 0.01$, the result of the iterations using Newton-Raphson method is shown in the Table 2.

Table 2
Computation of Interest Rate from the Iterations using Newton-Raphson Method

n	x_n	$\lvert x_n - x_{n-1}\rvert$
0	0.01	
1	0.007083841	-0.002916159
2	0.006272179	-0.000811662
3	0.006184499	-0.000087680
4	0.006183413	-0.000001086
5	0.006183413	-1.67242×10^{-10}

From Table 2, it is found that the interest rate is approximately equal to 0.006183413. This is because at 5th approximation, the error $|x_n - x_{n-1}|$ has a very small value of -1.67242×10^{-10}, that is close to zero. Hence, the interest rate for this scenario study is approximately 6.18%.

Conclusion

From this study, it is shown that Newton-Raphson method can be used in solving financial application such as finding the interest rate of study loan. In particular, the formula for the study loan is in the form of annuity that is a form of non-linear equation. Due to the difficulty in solving the interest rate in non-linear equation, this situation can be encountered by using Newton-Raphson method as a practical approach to estimate the unknown interest rate. The method demonstrated in this study could provide a guideline for students or clients who need financial aid to higher education to find out the comprehensive and affordable interest rate. Furthermore, the method and the scenario case presented in this study could be a reference for other researchers in financial applications.

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