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TIME VALUE OF MONEY AND MS EXCEL: CRITICAL TOOLS FOR THE UNDERLYING LOGIC OF PERSONAL FINANCE CALCULATORS

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Abstract

The primary objective of this paper is to throw light on one of the most importance concept during the wealth creation journey i.e. TIME VALUE OF MONEY (TMV) and to focus on the basic calculations which form the backbone for the different personal financial calculators showcased on the web as well mobile apps. The calculation to The concept of time value of money can be summarised in one line – The value of money today is less than it was yesterday, or in other words money available in hand now has more worth than the same money available in future. During the course of wealth creation, one must understand that for the number crunching to arrive at the future value of investment, present value of investment, amount to be invested at regular time periods or amount to be received at regular time periods in future, the bottom line is time value of money and its related concepts. There are multiple personal financing calculators which are mostly used as a market tooling by many financial advisors, wealth managers and asset management companies. However one should stay updated with the logical calculations behind these calculators. The paper would also highlight the logical calculations behind the multiple personal financial calculators which are available on the internet and quite widely used by the investor base. The base working of most of calculators has been elaborated using the applicable formulae in MS Excel in this paper. The paper also focus on the syntax of the formulas as well as the necessary examples so as to understand it from a practical perspective.

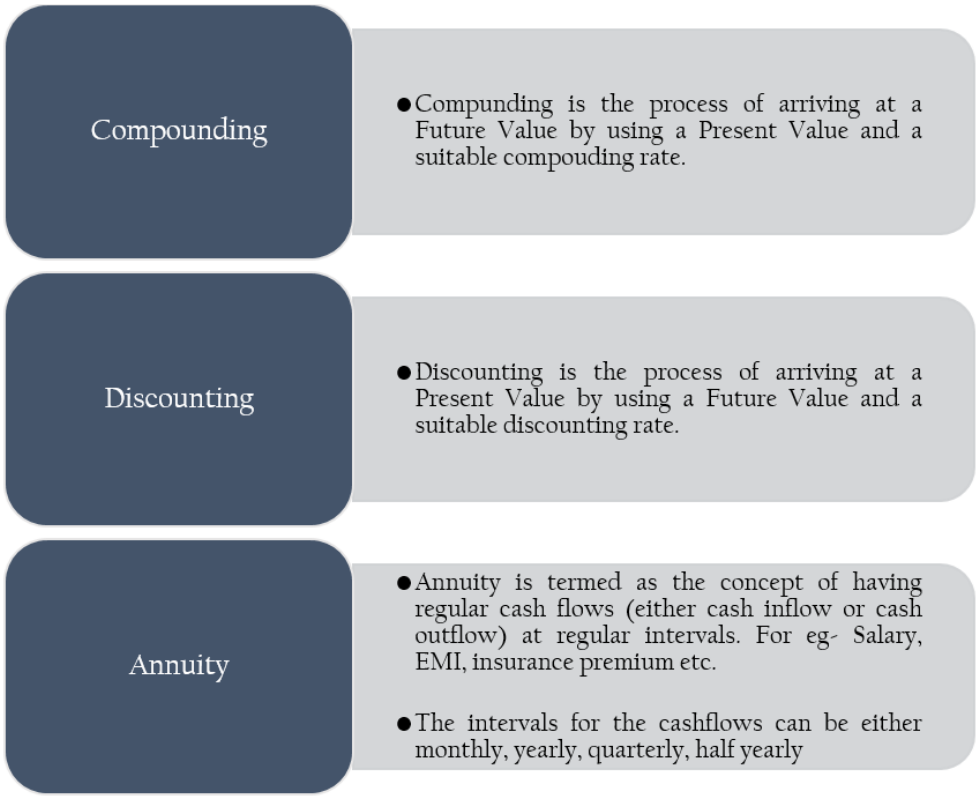
Keywords: Time Value of Money, Retirement Calculator, EMI Calculator, Inflation, Present Value, Future Value, Annuity, Nominal Rate, Real Rate, MS Excel.

INTRODUCTION TO TIME VALUE OF MONEY

We all remember our childhood times and the first thing which comes to our mind is the comparison of the cost of things or items at that time and the cost of the same items today. Over the years, we realise that the value of money has kept on going down and can be expected to go down in future as well. In short, a 10 rupee note today in hand has much less value as compared to a 10 rupee note 25 years back. This is basically what we call as time value of money.

Some of key terminologies associated with Time Value of Money are as elaborated below –

1) Compounding and Future Value
2) Discounting and Present Value
3) Annuity



The necessary formulae for the mentioned terminologies is as shown below.

Future Value | Present Value x (1+ Rate)^(time period)

Present Value | $\frac{\text{Future Value}}{(1+\text{Rate})^{(\text{time period})}}$

Present Value of Annuity | $\frac{\text{Annuity X } [(1+\text{Rate})^{(\text{time period})} - 1]}{\text{Rate x } (1+\text{Rate})^{(\text{time period})}}$

Future Value of Annuity | $\frac{\text{Annuity X } [(1+\text{Rate})^{(\text{time period})} - 1]}{\text{Rate}}$

Other key concepts to be highlighted here are the concept of Nominal Rate and Real Rate. Over the years, we can understand that the degradation in value of money is basically due to the impact of inflation on the economy. Inflation which is primarily termed as the increase in prices over the period, has a direct impact on the return generated through investment as it produces an effect on erosion. To elaborate this effect of inflation on the investment return, we need to understand the importance of nominal rate and real rate.

Nominal rate is defined as the general rate of return quoted on the investment products. So if we say the rate of return on fixed deposit is 8%, then 8% is the nominal rate of interest.

Real rate is defined as the rate of return after adjusting the effect of inflation on the Nominal Rate. So considering the above example of fixed deposit of 8% and assuming an inflation rate of 6%, the real rate of return can be calculated as follows –

(1+Nominal Rate) = (1+Real Rate) X (1+Inflation Rate)

Thus,

Real Rate = {(1+Nominal Rate) / (1+Inflation Rate)} – 1

Real Rate = {(1+0.08) / (1+0.06)} – 1

Real Rate = 1.9%

LITERATURE REVIEW

The time value of money (TVM) is a concept which says that money received today is more valuable than money received in future due to its potential earning capacity. (Vijay Joshi, 2019). Time value of money is one of the most talked about concept in the investment arena as a major part of the personal financial planning is based on the time value of money calculations based on certain underlying assumptions. As discussed by (Priya Purswani and Dr. Archana Singh) TVM becomes an important consideration for any financial or investment decision in every sector area and helps determining how time impacts the value of money. As rightly discussed by (Mr. Vikas Shrotriya, 2019), The purchasing power of money is also known as the value of money. Any change in the purchasing power of money over the period of time is known as the time value of money.

The concept of Time Value of Money has come over a long way and still very much the core concept of Financial Mathematics. As discussed by (Charles J. Delaney, Steven P. Rich and John T. Rose, 2016), over the last several decades the technology for teaching finance—specifically, the time value of money (TVM)—has advanced from published tables to hand-held financial calculators, spreadsheet (Excel) software, and now apps for smart phones.

Another thought process to be kept in mind about time value of money is the relationship between risk and return. As rightly highlighted by (Arline Cornelia Lobo, 2023) A fundamental point in the process to making investment decision is to understand the pattern of the relationship between expected return and investment risk. Primarily the risk and return possess a liner relationship which brings us to one the most important parameter of investment, the risk and return trade off. The risk and return trade off say that higher the risk, higher the expected return and vice-versa.

Most of the papers elaborated the concept of time value of money and the necessary calculations. However, the focus of my papers was to make understand how the personal financial calculators work, as most of retail class of investors access these calculators quite frequently while planning their finances.

OBJECTIVES OF THE PAPER

- To focus on the importance of time value of money concepts, its key parameters for creation of long term wealth.
- The logic of how the time value of money acts as a key catalyst for the different wealth management calculators available in the market.

- The major calculations of the different calculators and the number crunching behind them.
- To elaborate via number crunching, the effect on inflation on the long term wealth creation and how to apply the same. The motive to showcase this point is that the more we consider the realistic situation, the closer we move to the actual situation.

OVERVIEW OF FINANCIAL / WEALTH MANAGEMENT CALCULATORS

A financial calculator, unlike ordinary calculator, is mostly used for doing time value of money calculations. One of most commonly known financial calculator in the market is Casio FX 200v. Apart from financial calculators, the other most common tool available in the market for time value of money calculations in the MS-Excel. One important aspect which need to be understood is that whenever we are putting formulae in excel, we need to give requisite signs to the cashflow ('– 'for cash outflow and '+' for cash inflow).

Most of the wealth management and asset management companies across the globe have been providing different types of calculators on their websites as well as mobile applications for helping their clients in their wealth management, especially the number crunching part of their financial planning process. A typical wealth management calculator asks for the details such as the proposed investment amount, the expected tenure, risk appetite, expected rate of return, age etc.

Some of the most common known calculators available for the investor base, especially the retail class of investors are as mention below.

1. SIP Return Calculator
2. EMI Calculator
3. Retirement Calculator
4. Other Investment Calculators (Child Education, Vacation, Marriage)

As we all know that the importance of these type of calculators is number crunching, one should understand the critical back calculations performed by these calculators to showcase the output. Let's discuss the background number crunching done by these calculators.

SIP Return Calculator

SIP return calculator is the most basic form of calculator available. There are basically two key application of this calculator –

- To calculate the maturity value of an investment annuity with a defined rate of return and a defined time period.
- The calculate the rate of return earn per annum over the time period of investment and a defined maturity value. The rate of return calculated using this technique is also termed as Compounded Annual Growth Rate (CAGR).

Let us consider a suitable example for calculating both the above mentioned parameters

Practical Case (SIP)

A person started his first SIP as soon as he joined job. He decided to invest 5,000 per month in a mutual fund for a time period of 10 years. The past historical analysis of the mutual fund and the economy showed that the fund is expected to give a rate of return of 12%.

We need to know what would be the maturity value after 10 years.

The applicable MS Excel formula which need to be borne in mind is the Future Value (FV) formula. The syntax for the FV formula in excel is as shown below. The same need to be typed in excel.

=FV (rate, nper, pmt, pv, type)

Where

Rate = interest rate (make sure to convert them into monthly)

Nper = Time Period / total monthly instalments

PMT = Annuity Amount

Pv = Present value

Fv = Future value

In the captioned case here for SIP, we have the following parameters:

Table 1

Rate	12%
Nper	120 (12 investments in a year and for 10 years)
PMT	5000 (investment amount per month)
PV	0 (since this is the starting of the investment, the present value is 0)
Type	0 (if the investment is happening at the end of month) 1 (if the investment is happening at the beginning of month)

Now considering the above parameters as well as the formula stated above, we have the following. The formula needs to be typed in MS Excel:

= FV (12%/12,120,-5000,0,1)

= 1,161,695

The other parameter which the personal finance calculators help to calculate is the expected rate of return. In order to calculate the same, let us consider one more point in the previously mentioned case. Keeping all the parameters same, let assume the future value as 1,500,000 and we need to arrive at the rate of return.

The applicable formula to be used in MS Excel is the RATE formula. The syntax for the same is as shown below.

=Rate (Nper, pmt, pv, fv, type)

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In the captioned case, we have the following parameters:

Table 2

Nper	120 (12 investments in a year and for 10 years)
PMT	5000 (investment amount per month)
PV	0 (since this is the starting of the investment, the present value is 0)
FV	1,500,000
Type	0 (if the investment is happening at the end of month) 1 (if the investment is happening at the beginning of month)

Considering the above parameters, the expected rate of return on an investment of 5000 per month, for 120 months and the maturity value after 10 years is 500,000 is calculated using the Rate formula as follows –

=rate (120, -5000,0,1500000,1)

=1.35%

The rate obtained above is monthly since the investment is done on a monthly basis. Thus we to arrive at the annual rate, which can be obtained by multiplying the monthly rate by 12. Thus the annual expected rate of interest or CAGR is 16.2%.

EMI Calculator

The key parameters required for the EMI Calculator are:

1. Loan Amount
2. Tenure of Loan / Number of Instalments
3. Interest Rate of loan

The calculation is done using PMT formula is excel. The syntax of the PMT formula is as elaborated below. The same needs to be typed in MS Excel –

=PMT(rate, nper, pv, fv, type)

A better elaboration of the same can be done using a suitable example. Let's consider the following example –

Table 3

Loan Amount	1,000,000
Interest Rate Per Annum	10%
Tenure (Years)	10
Number of Installments	120 (10 X 12)

The next step involves using the above content in the PMT formula in MS Excel and accordingly we arrive at the Equated Monthly Installment amount.

Considering the above shared data and according putting the same in pmt formula of the excel, we have:

= PMT (10%/12,120, -1000000,0,0)

The EMI using above parameters come to 100,001.

Thus, whenever we are using a web based EMI calculator for arriving a loan EMI amount, the back calculation for the same is as per the PMT formula in excel.

Retirement Calculator

Retirement Calculator is one of the most sought after marketing tool used by investment advisor and wealth managers to showcase the important of having a peaceful retirement life by arriving at the calculated retirement corpus and the regular savings which should be done in a suitable investment instrument.

Most of the calculations are based on some pre-defined assumptions and these calculations are the benchmark used for comparing with the actual scenarios. The Retirement Calculator is generally used for calculating two major parameters –

1. Corpus required at the age of retirement
2. Amount of regular savings to be done from today in order to arrive at the targeted retirement corpus

Practical Scenario (Retirement Calculator)

A person's retirement age is 60 years, his current age is 40 years and expected life span is 85 years. His Current Annual expenses are 300,000. The assumption inflation rate is 6% and the expected return on the investment on the product here he is planning to put fund for his retirement corpus has interest rate of 9%. The primary task here involves calculating both the above mentioned parameters.

First Parameter: Corpus required at the age of retirement

His current annual expenses are Rs. 300,000, inflation rate of 6%. At the age of retirement, his annual expenses would be obtained by growing his current expenses using the inflation rate of 6%. So at the age of retirement, the monthly expenses would arrived by calculating the future value of this monthly expenses.

Thus the monthly expenses 20 years from now (when the person attains the age of 60 from the current age of 40 years)

= 300,000 X (1 + 6%)^20

= 962,141

Now once we have obtained the expected monthly expenses when the person attains the age of 60, the next consists of arriving at the amount of regular savings which should be in order to arrive at the targeted retirement corpus.

The annual expenses at retirement of Rs. 962,141. We understand that in order to arrive at the retirement corpus, we need to arrive at the present value of yearly annuity of 25 years (expected age of 85 years less retirement age of 60 years), considering the annuity amount of Rs. 962,141 and the rate of return to be considered here is the real rate (after adjusting the 6% inflation rate on the 9% rate of return).

Real Rate = [(1+0.09) / (1+0.06)] – 1 = 2.8%

Over the years, the effect of inflation cannot be ignored. Thus considering the real rate is more justified than the nominal rate of return. For arriving at the corpus at retirement, the applicable formula in excel is the Present Value formula or PV. The syntax for the PV formula in excel is as shown below. The same need to be typed in excel

=PV (rate, nper, pmt, fv, type)

The parameters of this formula have already been considered in the above EMI Calculator section. In this case, we have the following data points:

Table 4

PMT	962,141
Rate	2.8%
Tenure (Years)	25 years
Future Value (FV)	0 (since the retirement corpus is proposed to be over at the end of time period, thus future value is 0)
Type	1

The present value using above parameters and using the PV formula in MS-Excel we have:

=PV (2.8%, 25,-962141,0,1) = 17,613,197.

Second Parameter: Amount of regular savings to be done from today in order to arrive at the targeted retirement corpus

As per the above calculation, one can infer that the person would be needing 17,613,197 at retirement so that the annual expenses in retirement phase can be met properly, post considering the effects of inflation as well.

The second part of the retirement calculator involves arriving at the amount to invested on monthly basis (assuming) from today to arrive at the calculated retirement corpus of 17,613,197. As the requirement is calculating a fixed amount on a monthly basis, we need to calculate the annuity on a monthly basis.

As we need to calculated annuity, the applicable formula here is the PMT formula in excel. The following parameters are need to be considered and arrived at the retirement corpus.

Table 5

Future Value (FV)	17,613,197
Rate of Investment	9%
Tenure (Months)	240 (since the annuity needs to be calculated on a monthly basis)
Present Value (PV	0
Type	1

Considering the above parameters in the PMT formula and using the same in MS excel, we have the following:

=PMT (rate, nper, pv, fv, type)

=PMT (9%/12,240, 0, -17613197, 1)

=26,175

To sumarise the above calculations, in order to arrive a retirement corpus of Rs. 17,613,197, the person needs to invest monthly Rs. 26,175, considering his time to reach retirement of 60 years. One more point to be borne here is that the rates considered here are assumed and the original rates might differ.

Other Investment Calculators

As elaborated in the Retirement Calculator, the primary logic behind every investment calculators is nothing but amongst the number crunching using the key formulae as illustrated in the previous sections. For elaborating, let's take an example of child education calculator.

Suppose a couple has a child of 5 years and after 12 years, they wish to send him for abroad for education. The tentative current market cost for getting abroad education is INR 25 lakhs and the average inflation rate applicable for education is 10% per annum. So the expected cost after 12 years is arrived by increasing the current cost at 10% per annum. The amount comes to INR 78.5 lakhs.

Now, the primary outcome expected from the calculator is what should be the investment required to be done in a suitable investment product with an investment return of 13.2% per annum (assumed).

Table 6

Parameters	Value	Applicable Formula
Amount Needed for Education when the age of child is 5 years	2,500,000	
Assumed increase in the cost of education	10%	
Amount Needed at the age of 17	7,846,071	=2,500,000 X (1 +10%)^(17-5)
Expected Return on Investment	13.2%	
Expected Effective Monthly Return on Investment	1.1%	
Number of Months of Investment	144	
Amount to be Investment per month to arrive at the Corpus needed at the age of 17.	23,150	=PMT (1.1%,144,0,7846071,1) (the formula to be used in excel)

Thus, for having a corpus of INR 78.5 lakhs after 12 years, the investment to be done is INR 23,150 per month in an investment product having an average return of 12% per annum.

The same concept is applicable for Marriage Calculator, Vacation Calculator etc. Just that the applicable inflation rate might change but the underlying calculations remain the same.

CONCLUSION

The importance of these calculators do help a lot in goal based financial planning as we can attach proper value to a goal and according start the investment. Though most of the calculations are based on some assumptions which may change in the practical scenario, but the biggest advantage of understanding them helps an investor to have a disciplined approach towards investment. Once he / she gets the necessary clarity of these calculators, the investment journey is much stable and also the calculators are helpful for having a proper tracking and quantification of these goals in future.

The entire base for the calculations is the concept of time value of money and the understanding of the concept of compounding. The concept of compounding is like a backbone for the these calculators as for almost every type of calculation, the concept of compounding is applicable. Apart from the concept of compounding, one also need to keep in consideration, the impact of inflation rate. This is basically arrived by considering the real rate of interest and not the nominal rate.

Another point to be highlighted here is that all the input values required for the calculations are based on some basic assumptions. The bottom line to consider suitable assumptions based on the place of person's country as well as the investment environment there. One needs to have a proper background, historical as well as present market economic analysis to have an assumption which can be considered

realistic for arriving at a more prospective result. Thus, to conclude the more clarity a person has on the these concepts while planning for his finances, the better he/she is equipped to plan his investments and his liabilities more diligently for his present requirement as well as future.

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