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Use of Discounted Cash Flow Methods for Evaluation of Engineering Projects

Igor Pšunder

*Faculty of Civil Engineering, University of Maribor,
Slovenia*

1. Introduction

Research carried out in recent decades shows that the use of discounted cash flow (DCF) methods for engineering project evaluation has increased enormously. Klammer and Walker (1984) established in 1984 that in the USA the use of discounting grew from 19 percent in 1960 to 57 percent in 1970. Their research further stated that the use of discounted cash flow methods grew to 75 percent in 1980 for those projects dealing with the expansion of existing capacities. A few years later, Pike (1988) established that the use of either the internal rate of return or net present value methods in large UK companies grew from 58 percent to 84 percent between 1975 and 1986. Research carried out by Pšunder and Ferlan (2007 & 2008) among Slovenian project managers shows that the use of discounted cash flow methods depends on the project managers' field of education. Among project managers who have an education in civil engineering, only 50 percent use the net present value method and 66.7 percent the internal rate of return. Among mechanical engineers, 62.5 percent use the net present value method and 87.5 percent the internal rate of return.

Pšunder and Ferlan (2007) further established that among discounted cash flow methods – net present value (NPV), net present value index (NPVI), internal rate of return (IRR) and modified internal rate of return (MIRR) were taken into consideration – the most commonly used method in Slovene companies is the net present value method (average use is 70.5 percent), while the least popular is the use of the modified internal rate of return method (on average less than 30 percent). Employees with an education in mechanical engineering most often use the internal rate of return method (87.5 percent), followed by the net present value method (62.5 percent), while the modified internal rate of return method and net present value index is used by only half of these. The authors explain that the use of the internal rate of return method among experts with an education in mechanical engineering is explicable in terms of the method's ease of understanding, since the result is expressed in a percentage (of rate of return). At the same time, results can easily be compared between different projects and between different forms of other investments. Although the calculation demands trial and error procedure or interpolation, financial calculators and electronic spreadsheets contain standard procedures for internal rate of return calculation. The frequency of use of the net present value method can be explained by the simplicity of its calculation and by the generally widespread use of this method (a standard function on calculators and electronic spreadsheets).

Following on from this research, the modified internal rate of return method is the least used among the methods studied in the research, although this method avoids the deficiencies that occur with the internal rate of return method (e. g., one avoids the presumption that all payments are reinvested at the same rate of return as the internal one).

It is also interesting that the research showed that most experts simultaneously use a number of discounted cash flow methods, a technique which diminishes the possibility of false conclusions. 57.1 percent of experts with an education in mechanical engineering who evaluate investments by means of discounted cash flow methods most often use a combination of two methods, but only 35.7 percent of experts in other sciences use a combination of two methods.

Research also shows that, according to their personal opinion, project managers are not sufficiently aware of the limitations of discounted cash flow methods. In establishing the level of knowledge about flaws in discounted cash flow methods, Pšunder and Ferlan’s research (2007) established that less than half (43.2 percent) of experts (in all sciences) are familiar with multiple internal rate of return, and only 16 percent know the problem of results (conflicting advice) between the internal rate of return method and the net present value method. Major differences occur between experts of different profiles (Table 1).

Flaw	Mechanical engineering	Other technical sciences	Mathematical and natural sciences	Other
Conflicting advice of net present value and internal rate of return	37.5 %	33.3 %	0.0 %	43.8 %
Multiple internal rate of return	37.5 %	6.7 %	0.0 %	18.8 %
Deformation due to presumption that all payments are reinvested according to the rate of return identical to the internal one	37.5 %	40.0 %	20.0 %	56.3 %
Other	0.0 %	0.0 %	0.0 %	12.5 %

Table 1. Knowledge of flaws of discounted cash flow methods by field of education (Pšunder and Ferlan, 2007).

2. Theoretical background

We can divide project evaluation methods into two groups: a group of non-discounting methods and the discounting one. Among the most commonly used methods from the first group is certainly the payback period method.

Non-discounting methods contain several simplifications that can lead to flaws in results. It has to be stressed that non-discounting methods do not consider the time value of money. A cash inflow to be received in the future is weighed equally with a cash inflow to be received now. Since maturity of payments plays a significant role, this simplification can cause erroneous advice.

Non-discounting methods cannot be adopted for different risk levels, which means that only projects and investments with the same risk level can be mutually compared. Neither can

capital gain be included in the calculation. This means that non-discounting methods are based on the assumption that every investment will have the same capital gain or loss.

Despite the evident deficiencies of non-discounting methods, they are wide spread among project managers and other decision makers. According to Pšunder and Ferlan (2007), approximately 80 percent of project managers with an education in mechanical engineering and approximately two thirds of other project managers with an education in engineering (e.g., civil engineering or electrical engineering) are still using them.

In contrast to non-discounting methods, in the discounting ones the calculation is based on the time value of money. That means the differences in maturity of payments can be considered. With discounting methods, capital gain or loss can be included in the (last) payment of the project. Since the methods deal with a discount rate, the differences in the risk premium can be considered as well.

Discounting methods always deal with cash flow analysis of a project or an investment. There are several methods – e.g. the net present value index and modified internal rate of return method – but by far the most commonly used among the discounting methods are the net present value method and the internal rate of return method (Pšunder and Ferlan, 2007).

The main advantage of discounting methods over non-discounting ones is the consideration of the time value of money. This is particularly important in engineering projects where duration of projects is usually long, and payments can be vastly deferred. Thus, by using discounting methods for project analyses, we can overcome the time inconsistency of payments.

By using the net present value method, we compare the present value of future payments with initial investment. In this way we determine the surplus from a project or an investment in present value terms. The advice of the method is positive if the net present value of project or investment is greater than or equal to 0, which means a project or an investment will generate a surplus by a given discount rate. Since the risk premium is included in the discount rate, the surplus represents extra gain for the investor, measured in present value terms. Of course, the investor does not receive the sum immediately, but that “extra gain” represents the present value of future surpluses from the cash flow of a project or an investment. Mathematically, the net present value can be calculated by using equation 1:

$$NPV = -I_0 + \sum_{i=1}^n \frac{CF_i}{(1+r)^i} \quad (1)$$

In equation 1, CF_i stands for the cash flow in the period i , n represents the number of periods and r is the discount rate.

The internal rate of return method is quite similar to the net present value method, but despite these similarities, it produces different results. With the internal rate of return method, we calculate the return rate by equalizing the net present value with 0. The result is a measure of the rate of return earned on that capital used in the project during the time that the capital is used, after allowing for the recoupment of the initial capital outlay (Holmes, 1998).

According to Puxty and Dodds (1991) the internal rate of return method is no more difficult to understand. Though the mathematics are just as easy, it is trickier because in normal circumstances the solution can only be found by trial and error. The goal of the method is to

find an interest rate at which inflows exactly equal outflows. The internal rate of return is calculated from the following equation:

$$0 = -I_0 + \sum_{i=1}^n \frac{CF_i}{(1 + IRR)^i} \quad (2)$$

In equation 2, CF_i stands for the cash flow in period i , n means the number of periods and IRR is the internal rate of return.

With investment projects in engineering we often encounter a residual value when the life-cycle of the project or investment is ended. Ling and Archer (2008) emphasise that it is necessary to take into account the cash flow from the sale of a property and not only the periodic investment inflows of cash. In such cases, it is important to include in the last projected cash flow any potential (marketable) residual value of a project or an investment. Recent research by Pšunder and Cirman (2011) states that the residual value of an investment usually appears as a positive cash flow, but in some cases it can also be a negative one: for example, if we are dealing with the removal of a completely derelict property or a property with a very low value, then the cash outflows for the removal are greater than the inflows from the liquidated property.

Both the net present value method and the internal rate of return method derive from the same time value of money formula. However, they give a different type of indication. The net present value method gives an absolute size, while the internal rate of return method gives a relative indication. For optimal decision making, both methods should be used in practice. Both are valuable pieces of information in the decision process. In most cases, both the net present value method and the internal rate of return method will give the same advice (Brozik, n.d.).

3. Flaws in use of discounted cash flow models for evaluation of engineering projects

The net present value method principally does not contain any methodological assumptions or deficiencies that could impact the result of evaluation. However, the results are harder to understand in comparison to the percentage from the internal rate of return method. It would not be very meaningful if the investor were to determine that the net present value of a project or an investment were, for example, 25,000 EUR. It certainly may be difficult to compare this result with alternative investments, like real estate investment, bonds or cash deposits. It would be certainly more understandable if the result were expressed as a percentage of internal rate of return. This is probably the main reason that the internal rate of return method is often more popular.

In contrast to the net present value method, the theoretical findings identify numerous limitations connected with the internal rate of return method. The most significant are the following:

- reinvestment assumption,
- internal rates of return are non-additive,
- possibility of multiple internal rate of return,
- possibility of conflicting advice with the net present value method.

3.1 Reinvestment assumption

Reinvestment assumption means that all cash flows from the proposed investment are reinvested at the same rate of return as the internal one. Brozik (n.d.) explains that reinvestment assumption means that, if you are really going to get, e.g., an 8 percent return on the proposed investment, each cash flow must earn 8 percent for the life of the project. The more common way to state this is that, in order to achieve an 8 percent return on the entire investment, all cash flows must be reinvested at 8 percent until maturity. No cash flows can be diverted for other purposes. No better investments can be taken should they come along. The cash is essentially tied up for the life of the project, and you must find projects that will return 8 percent for the various time horizons each cash flow faces.

It is unrealistic to expect that all the cash flows from the proposed project will be reinvested at exactly the same rate of return as the internal one, which means that the internal rate of return will return distorted results. How intense the distortion will be depends mainly on the difference between the internal rate of return of the proposed investment and the reinvestment rate of return.

The problem can be overcome by using modified internal rate of return. However, although the modified internal rate of return method clearly overcomes several problems of the internal rate of return method, according to Pšunder and Ferlan (2007), it is the least popular discounting method among engineers. Half of mechanical engineers use the modified rate of return method for project or investment evaluation, but only 13.3 percent of engineers other than mechanical engineers do so. Moreover, only 37.5 percent of mechanical engineers are aware of the possibility of flaw in results due to reinvestment assumption.

3.2 Internal rates of return are non-additive

An interesting phenomenon in connection with the internal rate of return method is that we cannot add the internal rate of return of two projects; moreover, we get very surprising results when two or more combined projects are considered together. Several authors have discussed this in the past. Treynor and Black (1976) and after them Puxty and Dodds (1991) have found that inclusion of a third project can affect the choice between the first two.

Let's suppose we have two projects (A and B) and combine them with a third one (C), as shown in Table 2.

Project	I_0	PMT_1	PMT_2	IRR
A	-100	0	125	11.8
B	-100	110	0	10.0
C	-100	130	0	30.0
A + B	-200	130	125	18.0
B + C	-200	240	0	20.0

Table 2. Example of non-additivity of internal rate of return (modified from Treynor and Black (1976) and Puxty and Dodds (1991)).

If we compare project A and B, A is the better choice, as its internal rate of return is higher. But if we include project C and there are enough funds to finance both projects, the attractiveness of A and B change: B becomes preferable (Puxty and Dodds, 1991).

3.3 Multiple internal rate of return

Multiple internal rate of return is probably the best known flaw of the internal rate of return method. The problem is often experienced when the internal rate of return equation yields two (or more) results. Of course, in that case the mathematical result isn't meaningful for investment decision making purposes.

The reason for two or more results from the equation lies in its structure. The internal rate of return equation is a polynomial. Lumby and Jones (1999) explain that the fifteenth-century mathematician Descartes proved with his "rule of sign", that there are possible solutions to polynomial equation for each change of sign. Thus, any particular investment project may have more than one internal rate of return (i.e., there may be more than one discount rate that will reduce a project's cash flow to a zero net present value), or it may not have any internal rate of return at all.

In projects, where the cash flow can change the sign more than once among different periods, the internal rate of return method yields more than one root of the equation, which means more than one internal rate of return (Figure 1)

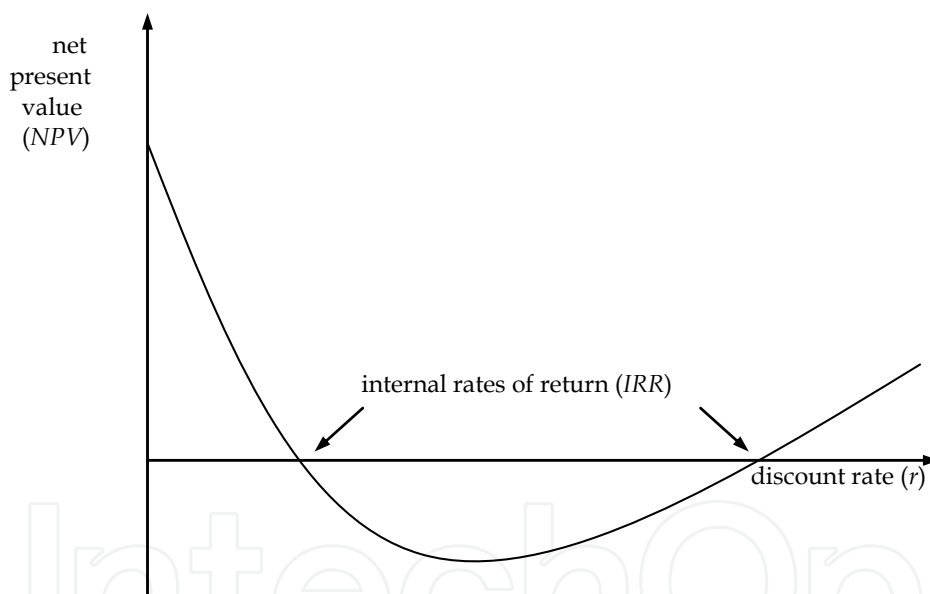


Fig. 1. Two roots of polynomial equation – multiple internal rate of return.

Several internal rates of return cannot form the basis for a justified decision, since the internal rates of return may differ several times. In cases of multiple internal rates of return, financial calculators and spreadsheet processing programs offer a choice of guessing the right internal rate of return; however, without knowing the theoretical process of avoiding multiple internal rates of return, this may not be the perfect solution either.

In theory, there are projects with conventional cash flows and projects with non-conventional cash flows. Puxty and Dodds (1991) explain that a conventional cash flow project is one where a cash outflow, or series of outflows, is followed by a cash inflow or series of inflows. A projects with a conventional cash flow has only one change in sign (+, -)

between the time periods. Non-conventional cash flows can therefore be defined as those that involve more than one change in sign. Such projects are due to modifications, reconstructions and overhauls, which require intensive investments that often cause negative cash flow, quite common in engineering projects.

The problem of more than one change in sign can be overcome with the elimination of second and further changes in sign by discounting such part of equation to the article of the equation with the same sign in cash flow as the discounted one.

A further possibility for overcoming the multiple internal rate of return problem, according Puxty and Dodds (1991), involves the net present value rule. It would have no difficulty in giving the correct advice: to reject the project because it has a negative net present value or to accept it because it has a positive one at the given discount rate.

In connection with the internal rate of return, it is worth mentioning at least one further problem: a non-existent internal rate of return. Since the problem is very unlikely to appear in practice, we will not give it any in depth attention.

According to Pšunder and Ferlan's (2007) research among Slovenian project managers, only 37.5 percent of project managers with an education in mechanical engineering know about the multiple internal rate of return problem.

3.4 Conflicting advice of the net present value and the internal rate of return

Sometimes it becomes necessary to compare two projects in practice. In such cases the net present value and the internal rate of return may give opposite advice. To understand why the results of both methods differ, it is necessary to present the lines of two projects in a diagram (Figure 2).

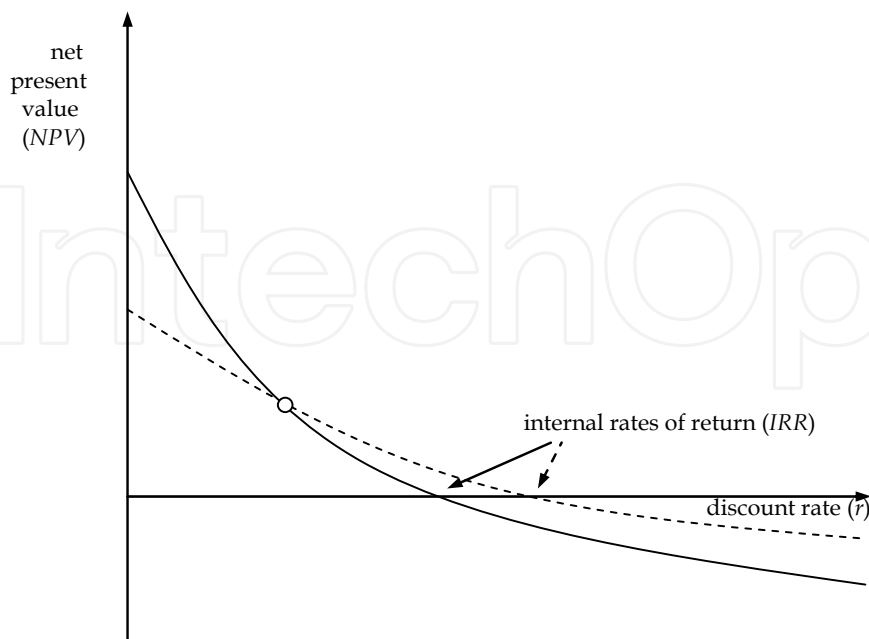


Fig. 2. Conflicting indication from net present value and internal rate of return (modified from Holmes, 1998).

The two curves belonging to two projects cross at a certain discount rate. Above this rate, the full line belongs to the superior project, below this rate, the dotted line represent the better investment. Puxty and Dodds (1991) explain the reason: the bulk of cash inflows from the project with the dotted line arrives in the later years, and hence at higher rates of interest, they are discounted more heavily.

Holmes (1998) writes that the reason for conflicting advice is the two techniques make different assumptions regarding what will happen to cash inflows from investment projects. According to his findings, in such cases the net present value rule gives the correct advice.

According to their own opinion, only 37.5 percent of Slovenian projects managers with an education in mechanical engineering, 33.3 percent of Slovenian project managers with education in other technical sciences, and 43.8 percent of project managers with other education know the problem of conflicting advice from the net present value method and the internal rate of return method (see Table 1).

4. Impact of the discount rate on engineering project evaluation

Pšunder and Cirman (2011) claim that the key factor in estimating the present value of future cash flows is the discount rate. If it were 0, the net present value equation (equation 1) would be reduced merely to the addition and subtraction of cash flows during different periods, without considering the time value of money. The discount rate determines the required rate of return that an investor demands for a certain investment in accordance with the risk associated with the investment, and it has a profound impact on the net present value. A higher discount rate results in a reduction of the net present value, whereas a lower one results in its increase, an effect that is evident in Figure 3.

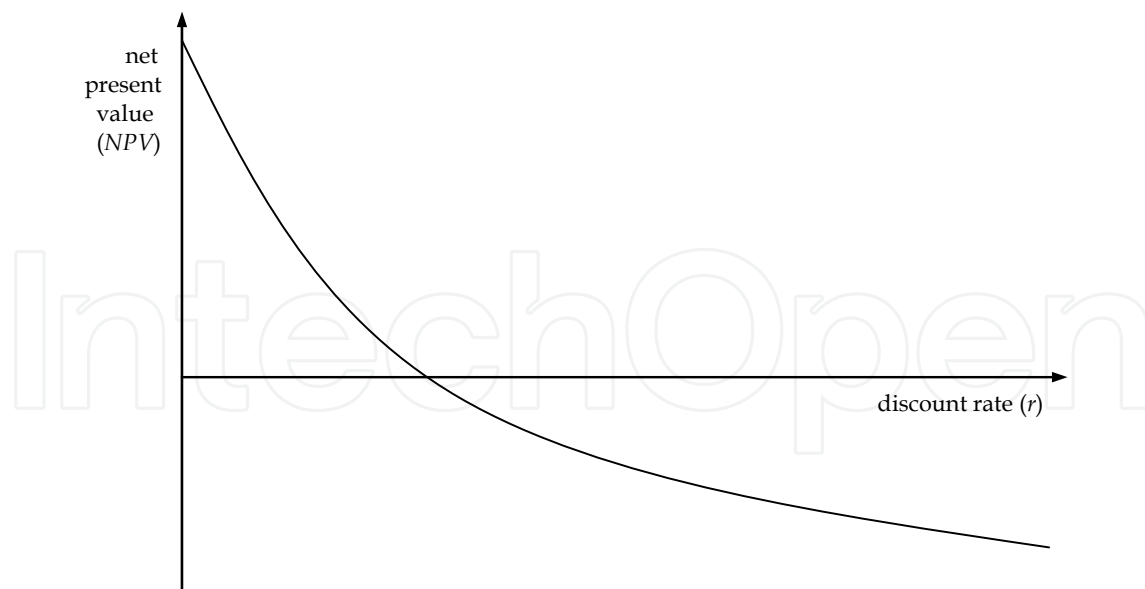


Fig. 3. Influence of the discount rate on the net present value.

From Figure 3 we can see the relationship between the net present value and the internal rate of return. When increasing the discount rate, the net present value decreases. When the net present value reaches 0, the discount rate is equal to the internal rate of return.

Pšunder and Cirman (2011) state that the discount rate is the rate at which future cash flows are converted into their present value. The differences between the discount rates have significant impact on the result of investment or project analysis. The contemporary theory of the determination of the discount rate favours a more precise definition of the discount rate. As the discount rate does not include a capital recovery premium, it can only be used for assessing an investment where we do not expect changes in the value of the investment, or where we can expect that changes in the value of the investment will be considered when selling property or at the termination of the investment (adopted from Friedman and Ordway, 1989, and The Appraisal of Real Estate, 2008). Ling and Archer (2008) emphasize that it is also necessary to take into account the cash flow from the sale of a property and not only the periodic investment inflows of cash. In such cases, it is important to include in the last projected cash flow any potential (marketable) residual value of an investment. The latter usually appears as a positive cash flow, but in some cases it can also be a negative one; for example, if we are dealing with the removal of a completely derelict property or of a property with a very low value, then the cash outflows for the removal are greater than the inflows from the liquidated asset.

By definition, the discount rate represents the rate of return that can be obtained in the financial market for a similar investment with comparable risk. What rate of return will be required for a certain investment depends on the risk associated with the specific investment and on the rate of return on investments with a comparable risk (Mramor, 1993).

According to Pšunder and Cirman (2011), different risk premiums must be taken into account for different projects, enabling us to compare two quite different projects. Certainly, machinery and equipment investments are mostly subject to deterioration and obsolescence, which are the reasons an investment loses value in the long run. The loss of value can be included in cash flow from the residual value (the last cash flow in the equation when individual cash flows can be considered).

Pšunder and Cirman (2011) write that the discount rate has a significant influence on the result of the present value method; that is why the correct choice of a discount rate is a precondition for an appropriate analysis.

The above mentioned authors state that when analyzing a certain project, the size of the initial investment, expected cash flows and estimated duration of the project are known. The key factor that influences the result of the analysis is the discount rate. The discount rate is a decisive factor when evaluating whether projects are acceptable or not. The impact of the applied discount rate significantly increases with the duration of a project.

Presuming a limited period until the end of the project and constant annual cash flow of the project, we can derive a present value of future annuities (PVFA). In the case of these presumptions, the equation 1 takes following form:

$$NPV = -I_0 + \sum_{i=1}^n \frac{CF}{(1+r)^i} = -I_0 + CF \cdot \sum_{i=1}^n \frac{1}{(1+r)^i} \quad (3)$$

In equation 3, CF stands for the constant annual cash flow, n represents the number of periods and r is the discount rate.

On the right side of the equation a geometrical sequence is seen:

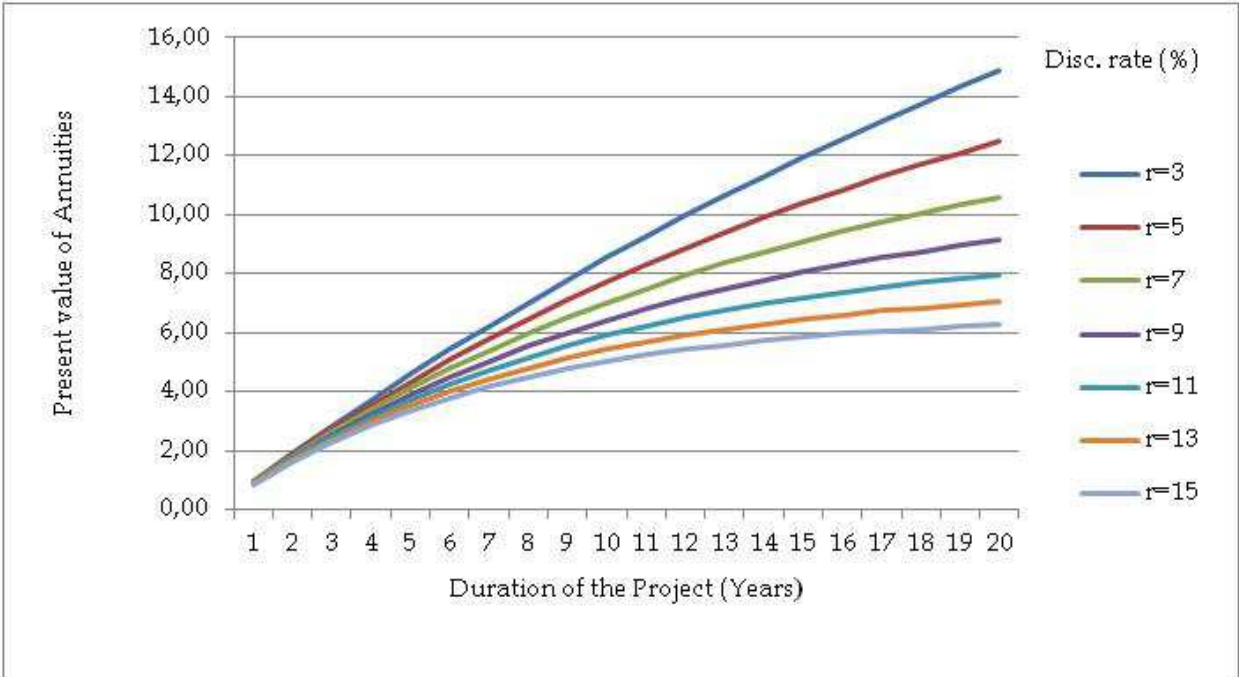
$$\sum_{i=1}^n \frac{1}{(1+r)^i}$$

The sum of the geometrical sequence can be written at limited number (*n*) of articles as:

$$\frac{(1+r)^n - 1}{(1+r)^n \cdot r} = PVFA \tag{4}$$

In the above equation, *r* stands for the discount rate and *n* represents the number of periods. The PVFA represents the present value of the future annuities factor at limited number of periods.

The impact of the discount rate on the present value of future annuities factor with regard to the duration of a project is shown in Graph 1.



Graph 1. Factor of the present value of future annuities in relation to the discount rate and the duration of a project (Pšunder and Cirman 2011).

The above graph shows that the difference in the discount rate exerts a greater impact on projects with a longer duration, and that the differences are larger when using lower discount rates that result in higher factors of the present value of constant cash flow series (future annuities). In the case of an investment with a 20-year depreciation period (the duration of the investment is adapted to the depreciation period), it can be established that the present value of annuities at a 3 percent discount rate totals 14.88, which is over 50 percent greater than at a 9 percent discount rate with a present value factor of 9.13. This is twice the factor of the present value at a 13 percent discount rate. At the same time, this means that, in the interval of discount rates between 3 percent and 13 percent large errors

can be made in the assessment of the present value of cash flows, which can certainly result in an incorrect decision based on the analysis (Pšunder and Cirman, 2011).

In addition to the above graph, the present value of future annuities using discount rates of 3 percent to 15 percent for selected investment durations is shown in Table 3.

Discount rate (r)	Project duration (years)						
	1	3	5	7	10	15	20
3	0.97	2.83	4.58	6.23	8.53	11.94	14.88
4	0.96	2.78	4.45	6.00	8.11	11.12	13.59
5	0.95	2.72	4.33	5.79	7.72	10.38	12.46
6	0.94	2.67	4.21	5.58	7.36	9.71	11.47
7	0.93	2.62	4.10	5.39	7.02	9.11	10.59
8	0.93	2.58	3.99	5.21	6.71	8.56	9.82
9	0.92	2.53	3.89	5.03	6.42	8.06	9.13
10	0.91	2.49	3.79	4.87	6.14	7.61	8.51
11	0.90	2.44	3.70	4.71	5.89	7.19	7.96
12	0.89	2.40	3.60	4.56	5.65	6.81	7.47
13	0.88	2.36	3.52	4.42	5.43	6.46	7.02
14	0.88	2.32	3.43	4.29	5.22	6.14	6.62
15	0.87	2.28	3.35	4.16	5.02	5.85	6.26

Table 3. Factors of the present value of future annuities in relation to the discount rate and the duration of an investment (Pšunder and Cirman, 2011).

5. Applicability in practice

Kušar et al. (2008) state that the result of work by the project team in mechanical engineering is an estimate of the economic justification and feasibility of the project, including risk analysis. It is almost unavoidable to use discounted cash flow methods for estimating the economic justification. As found in the theoretical background of this chapter, the use of non-discounted methods would embody all the flaws of the group of methods, including avoiding the time of the money principle and risk sensitivity.

Using the discounting methods leads to much more trustworthy results, but with some limitations which are specific to engineering projects. As found by Pšunder and Ferlan (2007), the most commonly used methods among discounting ones are the net present value method and the internal rate of return method. Project managers with an education in mechanical engineering use the internal rate of return even more frequently.

5.1 Multiple internal rate of return in engineering projects

The structure of cash flows in engineering projects often leads to non-conventional cash flows. As seen in Figure 4, the sign of cash flow often changes, owing to maintenance and overhauls.

The problem of more than one change in sign leads to multiple internal rates of return. Multiple internal rates of return do not mean uniform advice, so a decision about economic justification of the project cannot be made.

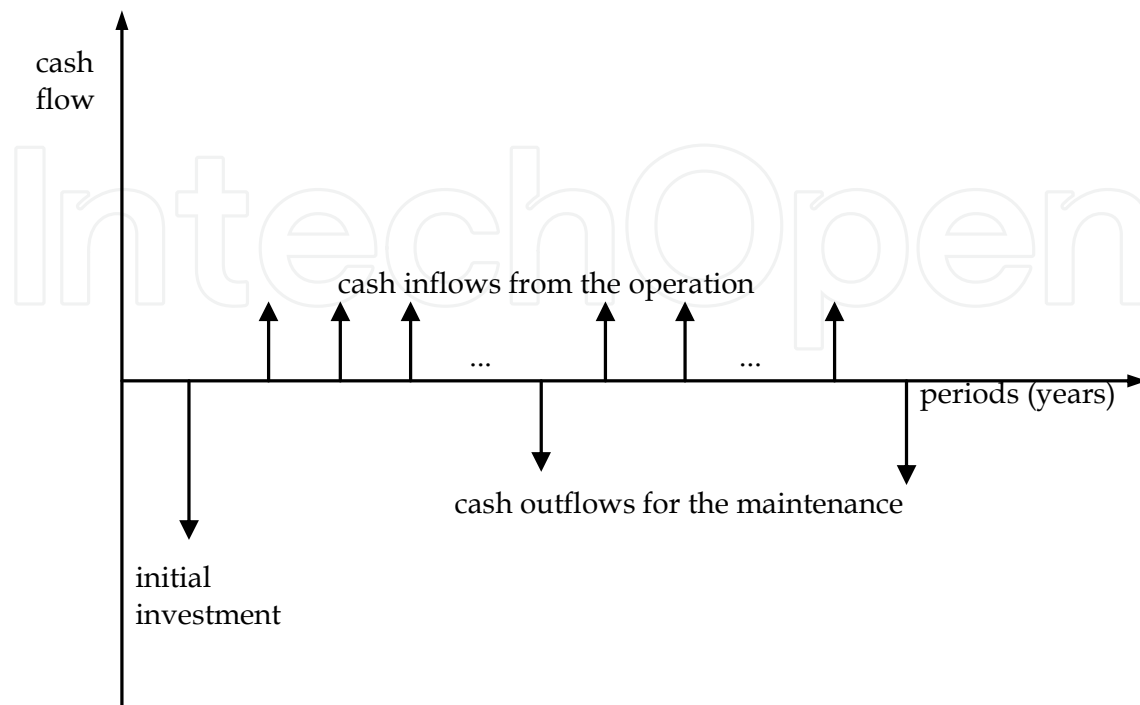


Fig. 4. Non-conventional cash flows in engineering projects, owing to maintenace and overhauls.

According to Pšunder and Ferlan (2007) only slightly more than one-third of mechanical engineers are acquainted with multiple internal rate of return, so overcoming the multiple internal rate of return can cause problems in practice. However, the problem can be overcome by discounting the article with the change of sign to the period, represented by the article of the same sign in cash flow as the discounted one. A further possibility for overcoming the multiple internal rate of return problem is, according to Puxty and Dodds (1991), using the net present value rule. It would have no difficulty in giving the correct advice.

5.2 Use of the discount rate

The net present value method has numerous advantages over the internal rate of return method. Above all, it is simpler to calculate and it isn't sensitive to the flaws arising from the multiple internal rate of return, the non-additive internal rate of return and other specific flaws that are associated with the internal rate of return method.

However, although we can avoid all the flaws of the internal rate of return method when using the net present value method, we encounter a problem of setting up the discount rate.

Let's take a case study on an investment project with a duration of 20 years. For easier calculation, a presumption of constant annual cash flow is made. A project is feasible when the net present value, calculated from equation 3, is equal to or higher than 0.

In a 20-year project, the constant cash flow at a discount rate of 10 percent must amount to at least 10.6 percent of the investment on the annual level in order for the analysis to provide a positive indication. Meanwhile, at a 15 percent discount rate, it needs to be approximately 1.5 times as high, as seen from Table 4.

Discount rate (r)	Project duration (years)		
	5	10	20
5	0.130	0.080	0.065
6	0.136	0.087	0.073
7	0.142	0.094	0.081
8	0.149	0.102	0.089
9	0.156	0.110	0.097
10	0.163	0.117	0.106
11	0.170	0.126	0.115
12	0.177	0.134	0.124
13	0.184	0.142	0.133
14	0.192	0.151	0.143
15	0.199	0.160	0.152

Table 4. Constant annual cash flows necessary (as a proportion of the initial investment outlay) for a positive indication of the present value analysis (modified after Pšunder and Cirman, 2011).

When a 20-year project generates a constant annual cash flow that amounts to 10 percent of the investment on the annual level, the net present value will be higher than 0 at a discount rate of 9 percent, but lower than 0 at a discount rate of 10 percent. The advice from the method will change, owing to changes in the discount rate. This example shows how important precise setting of the discount rate is.

The impact of the discount rate is comparatively diminished when projects are shorter and when the discount rate level is higher. However, even with 5-year projects and discount rates over 10 percent, the setting up of the discount rate could be decisive for the advice from the net present value method.

The survey conducted in February and March 2011 among appraisers in Slovenia by Pšunder and Cirman (2011) shows that experts have a quite unified opinion about the risk free rate. The average nominal risk-free rate in the survey was 4.20 percent. This average corresponded to the returns on bonds issued by the Republic of Slovenia with a maturity of seven to eight years. By using the calculated average real rate of return, they established that the respondents' average expected future inflation was 2.25 percent, which means the respondents expect slightly higher inflation in Slovenia than the target inflation set by the

European Central Bank (2.00 percent). The univariate statistics on risk-free rates of return are presented in Table 5.

Risk-free rate	Mean	Std. Dev
Nominal rate	4.20	1.25
Real rate	1.91	0.74
Expected inflation	2.25	

Table 5. Risk-free rates of return and expected inflation (Pšunder and Cirman, 2011).

The experts’ opinion was not so unified considering the risk premium. The experts considered the risk premium for improvements (additions to building etc.) at 4.91 percent (mean). The standard deviation was 3.07. As the risk premium is added to the risk free rate when calculating the discount rate, the discount rate may also vary immensely. Consequently the net present value method might give very varying advice when used.

6. Discussion and conclusion

Research conducted by Pšunder and Ferlan (2007) about knowledge of faults in investment project evaluation methods shows that, regardless of the field of education, non-discounting methods are still more popular than discounting methods. The research also shows that experts who have an education in mechanical engineering and are involved in investment project evaluation are more likely than average to use discounting methods. They also possess above-average knowledge about deficiencies in investment project evaluation methods. In using the internal rate of return method, experts with an education in mechanical engineering are most familiar with multiple internal rate of return. The level of familiarity with the multiple internal rate of return is above average, most probably because big projects in the field of mechanical engineering are, owing to variable cash flow, typically subject to multiple internal rate of return.

Discounting methods are far more precise in advice about investment projects than non-discounting methods; however, the discounting methods have their flaws and drawbacks, as well. In particular, internal rate of return has numerous drawbacks that can lead to incorrect conclusions. The most frequent drawbacks involve multiple internal rates of return, reinvestment assumptions and non-additive projects.

These drawbacks of the internal rate of return method are the reason that the net present value method is the better method of the two. It is easy to calculate, but results are harder to understand in comparison to the percentage from the internal rate of return method. It certainly may be difficult to compare the result with alternative investments.

The discount rate is a key factor in proposed project analysis. The size of the discount rate can greatly influence decisions about an investment, since even small changes in the discount rate can dramatically change a decision about the acceptance or rejection of an investment. This is why its determination needs experience and should not be left to practice-based approximations. The proper application of the net present value method is based on the accuracy of the applied discount rate. Recent research shows that experts’

opinions about risk free rate are quite unified, but not by the risk premium (Pšunder and Cirman, 2011).

Despite the wide use of discounting methods, there is still incomplete knowledge about them. To ensure the reliability of discounting methods, project managers must be acquainted with the deficiencies and drawbacks of the methods, particularly of the internal rate of return method. With the net present value method, it is vital to apply professionally proven methods when establishing the discount rate. Only this will ensure that the results of the analysis will be reliable and credible.

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University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
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InTech China

Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
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