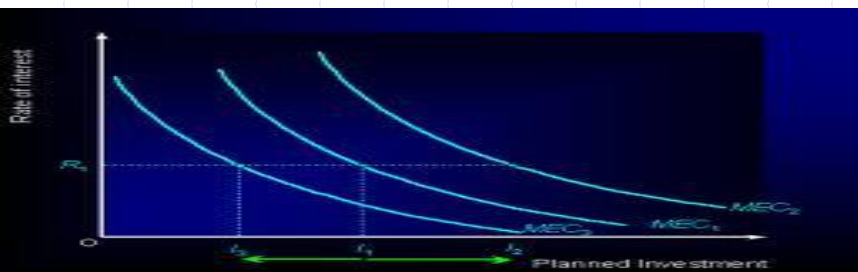


Project Cost Management

Investment Appraisal / Discounted Cash Flow (DCF) - The Present Value of £1

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The Present Value of 1

The value today of a sum of money which is either receivable or payable at the end of a specified period of time given a specified rate of interest.

Formula

$$P = A * \frac{1}{(1+r)^n}$$

Where:

P = the Present Value

A = Future Value

r = the rate of discount

n = the number of years.



Example: The Present Value of 1

If interest rates were standing at 5% and you were given the choice of receiving £1,000 now, or £1,250 in five years time, which would leave you better off?

Method: .

Either work out the amount to which £1,000 would accumulate over 5 years at 5%, and if it is greater than £1,250, then choose £1,000 now, or discount £1,250 back to present value at 5%, and if it is greater than £1,000 then choose £1,250 in 5 years time:

$$\begin{aligned}\text{Amount of 1,000 in 5 years @ 5\%} &= 1,000 * (1.05)^5 \\ &= 1,276\end{aligned}$$

Example: 1 The Present Value of 1 (cont.)

or

$$\begin{aligned}\text{PV of 1,250 for 5 years @ 5\%} &= 1,250 * \frac{1}{(1.05)^5} \\ &= 1,250 * 0.7835 \\ &= 979.40\end{aligned}$$

What these calculations show is that if we invested the £1,000 at 5% for 5 years then the resultant fund would be £1,276 at the end of 5 years - £26 greater than the alternative. £1,000 now is obviously to be preferred to £1,250 in five years time on this basis. Had the alternative to £1,000 now been £1,276 in 5 years time, then we would have been (theoretically at least) absolutely indifferent as to choice as our wealth in 5 years would have been the same whichever choice we made.

The Present Value of 1 (cont.)

- The above approach compares the alternatives by calculating their values 5 years into the future. Another approach is to compare their values now by discounting the £1,250 back to present value. The option of receiving £1,000 now obviously has a present value of £1,000. £1,250 receivable in 5 years time has a present value of only £979.40, £26 less than the alternative. Again we would be better off choosing to take the £1,000 now option. At a discount rate of 5% the option to receive £ 1,250 in 5 years time is not worth as much as the option to receive £1,000 straight away.

Note: The use of the word "**discount**". The previous examples in Section I (previous slide – Amount of £1) all related to situations where we were projecting today's values forward to some future date and quantifying the effect that the application of compound "interest" would have. In this section we are reversing this process, i.e. bringing future values back to present day values, again taking account of the effects of interest charges in the interim. By convention we refer to the rate of interest when it is used in this manner as the *rate of discount*.

Example: 2 – The Present Value of 1

If you were to be offered the choice of being given (a) £2,500 in 10 years time, or (b) £3,500 in 15 years time, which would be the most advantageous to you to accept, given that money can presently be invested at a long term rate of 6% pa?

Method:

It is obviously not possible to make direct comparisons between the two sums of money because they arise at different points in time which means that account has to be taken of the fact that a true comparison would include the potential for earning interest on £2,500 between years 10 and 15. The way we deal with this is to ask the question: "How much would we need to have today such that if we invested it at 6% we would have a fund of £2,500 in ten years time, and would that sum be greater than or smaller than the sum we would need to invest today at 6% to achieve £3,500 in 15 years time?". In other words, we need to calculate the Present Values of the two options.

Example: 2 – The Present Value of 1(cont.)

Formula:

$$P = 2,500 * \frac{1}{(1+r)^n}$$

Substituting (a)

$$P = 2,500 * \frac{1}{(1.06)^{10}}$$

$$P = 2,500 * 0.5584$$

$$P = 1,396$$

Example: 2 – The **Present Value of 1(cont.)**

Substituting (b)

$$P = 3,500 * \frac{1}{(1.06)^{15}}$$

$$P = 3,500 * 0.4172$$

$$P = 1,460$$

What the above tells us is that option (b) is to be preferred as it has a higher Present Value than option (a). Given an interest rate of 6%, the option of receiving £2,500 in 12 years time is worth only £1,396 today, whereas the option of receiving £3,500 in 15 years time is worth £1,460 today.

The decision rule in these cases where we are considering alternative future benefits is that the option with the **highest** Present Value should be chosen. .

Costs in Use

- Using the above methodology we can start to tackle some of the more common problems found in the realms of construction economics.

Example:

Over a period of 20 years would it be financially more efficient to install maintenance free windows at a cost of £1,000 each, or windows which cost £600 initially but £200 every 5 years when they needed to be painted? Money to finance either option is available at 10%.

Method:

Work out how much would be needed now to cover the total costs of each option and choose the option that has the lowest Present Value. Note that the rule has changed now that we are evaluating future costs rather than benefits.

Costs in Use (cont.)

Maintenance Free

Year	Cost	PV of 1 @ 10%	PV
0	1,000	1.0000	1,000
5			
10			
15			
20			

Total 1,000

Maintenance Prone

Year	Cost	PV of 1 @ 10%	PV
0	600	1.0000	600
5	200	0.6209	124
10	200	0.3855	77
15	200	0.2394	48
20		0.1486	0

Total 849

To cover the costs of the **maintenance-free option** would cost £1,000 spent at the outset with no more to pay for the lifetime of the project. If, however, we had only £849 available now we could cover all the costs of the alternative by spending £600 initially and investing the balance of £249 at 10% to pay for the painting costs which arose in years 5, 10 and 15. Effectively we would be using the interest earned on this money to pay for the majority of the painting costs. This can be demonstrated thus:

Costs in Use (cont.)

Year	Interest (5 yr @ 10%)	Size of fund at yr end	Withdraw	Carry forward
0		849	600	249
5	152	401	200	201
10	123	324	200	124
15	76	200	200	0
20	0	0		0

On this evidence, the option with the lowest Present Value is the one to choose in that it could be financed out of a smaller initial sum than its alternative.

It could be argued that the above calculation is misleading because it does not take account of inflation of the painting costs. Including an allowance for inflation is not a problem. Predicting the allowance that should be made is much more difficult. Leaving aside the problem of prediction; we simply revert to the Amount of 1 formula to adjust the future cost figures. Assuming a rate of inflation of 5%, the Present Values of the options could be recalculated quite easily:

Sensitivity analysis

Maintenance Free:

Year	Cost	PV of 1 @ 10%	PV
0	1,000	1.0000	1,000
5			
10			
15			
20			

Total 1,000

Maintenance Prone:

Year	Cost + Inflation @ 5%	Cost + Inflation @ 5%	PV of 1 @ 10%	PV
0	600	600	1.000	600
5	200	255	0.6209	158
10	200	326	0.3855	126
15	200	416	0.2394	100
20		0	0.1486	0

Total 984

see Amount of £1 table provided

Even having made an allowance for inflation, the maintenance prone option has a lower Present Value and should, on this basis, be selected.

Net Present Value:

The above examples are relatively simple in that they involve making straightforward either/or decisions. In practice it is frequently the case that there is no second option against which to measure performance.

Example:

You have been offered an investment opportunity which will require you to spend £10,000 initially to obtain returns as follows:

Year	Income
1	0
2	3,000
3	4,000
4	3,000
5	2,000

Net Present Value (cont.)

If we add the initial investment to the above, and present the proposal in convention cash flow format, it would look like this

End of Year	Expenditure	Income	Net Cash Flow
0	-10,000		-10,000
1		0	0
2		3,000	3,000
3		4,000	4,000
4		3,000	3,000
5		2,000	2,000

Net Value = 2,000

We have added another year to the sequence. This year (Year 0) represents "now" (strictly speaking, the end of the year preceding Year 1), or the first day of the time period over which the analysis will take place. Year 1 represents one full year after Year 0, Year 2 represents two full years after Year 0 etc. The "Net Value" is simply the sum of the Net Cash Flows, in other words, the surplus of the positive cash flows over the negative cash flows.

Net Present Value (cont.)

What we now have to do is to satisfy ourselves whether or not the proposition is worth while. To do this we have to establish whether or not the income is coming in quickly enough to pay back the initial capital expenditure and interest on it. This is done by discounting all the cash flows, positive and negative, back to their present values – i.e. by calculating the Net Present Value of the project. The discount rate which is used (10%) represents either the cost of borrowing the money used to finance the project, or the cost of foregoing interest by investing elsewhere.

End of Year	Expenditure	Income	Net Cash Flow	PV of 1 @ 10%	Discounted Cash Flow
0	-10,000		-10,000	1.0000	-10,000
1		0	0	0.9091	0
2		3,000	3,000	0.8264	2,479
3		4,000	4,000	0.7513	3,005
4		3,000	3,000	0.6830	2,049
5		2,000	2,000	0.6209	1,242

Net Present Value = 1,225

Net Present Value (cont.)

The project has a *negative* NPV and should *not* be proceeded with. What this means is that in this particular case we would be better off investing the £10,000 at 10% for five years elsewhere than investing in this project. It is certainly not worth borrowing for. Although the project delivers a total income of £12,000, the surplus of £2,000 is insufficient to cover the interest charges on borrowed money and is not as much as could be made by investing elsewhere. We can show this by working through what would happen if the money were to be borrowed and paid back out of the receipts of the project:

Borrow and invest in the project:

End of Year	Cash Flow	Interest @ 10%	Cumulative + Interest
0	-10000		-10,000
1	0	-1,000	-11,000
2	3000	-1,100	-9,100
3	4000	-910	-6,010
4	3000	-601	-3,611
5	2000	-361	-1,972

Net Present Value (cont.)

By the end of year 5 the borrower would still be £1,972 in debt (i.e. the project has a *Net Terminal Value* of minus £1,972) as the interest charges mount up faster than the income from the project can pay them off. The Present Value of this sum at 10% is £1,225.

Were we have to revise the pattern of the cash flows such that the returns came in earlier, then a different result would emerge:

Borrow and invest in revised project:

See tables below

Net Present Value (cont.)

Borrow and invest in revised project:

End of Year	Net Cash Flow	PV of 1 @ 10%	Discounted Cash Flow
0	-10,000	1.0000	-10,000
1	6,000	0.9091	5,455
2	4,000	0.8264	3,306
3	1,000	0.7513	751
4	1,000	0.6830	683
5	0	0.6209	0

End of Year	Net Cash Flow	Interest @ 10%	Cumulative + Interest
0	-10,000		-10,000
1	6,000	-1,000	-5,000
2	4,000	-500	-1,500
3	1,000	-150	-650
4	1,000	-65	285
5	0	29	314

Net Present Value= 195

Present value of 314 for 5yrs @ 10% = 195

Here the Net Value is the same (£2,000), but the big returns are made early in the project. In DCF terms they are less heavily discounted and therefore contribute more to the NPV. As a result the NPV is *positive* which means that at 10% the project should be considered favourably.

Amount of 1 pa

The amount to which £1 invested at the end of each year will accumulate at the specified interest rate by the end of a specified number of years.

Formula:

$$A = \frac{(1+r)^n - 1}{r}$$

Where:

A = the final sum

r = the rate of interest pa

n = the number of years.

Amount of £1 pa

Example:

If you were to invest £123 per year, starting at the end of the first year and adding to the fund at the end of each year, how much would you have at the end of 12 years if interest rates were a constant 8%?

$$A = \frac{(1.08)^{12} - 1}{0.08} * 123$$

$$A = 18.977 * 123$$

$$A = 2334.19$$

At the end of 12 years the fund would stand at £2,334.19.

The formula can, of course, be adjusted to take account of sub-annual compounding periods in the same way that was used to adjust the Amount of 1 formula. If an adjustment is needed to take account of the first payment being made immediately rather than at the end of the first year, then add 1 to the number of years.

The Present Value of £1 pa

The value today of a stream of payments / receipts which are made / received at the end of each year for a given number of years at a given rate of discount.

Formula:

$$P = \frac{1 - \frac{1}{(1+r)^n}}{r} * C$$

Where:

P = the Present Value

C = the constant amount pa

r = the rate of discount pa

n = the number of years.

The Present Value of £1 pa (cont.)

Example:

How much would I have to set aside today in a fund which paid 10% interest annually so that I could take out of the fund £ 1 00 at the end of each year for the next 6 years?

Substituting:

$$P = \frac{1 - \frac{1}{[(1+0.1)^6]}}{0.1} * 100$$

$$P = 4.3553 * 100$$

$$P = 435.53$$

That is, if I invested £435.53 into a fund yielding 10%, I could take out £100 pa for six years and there would be nothing left at the end. Again, proof of this is quite easy to establish by working the figure back: 22

The Present Value of £1 pa (cont.)

End of Year	Interest (1 yr. @ 10%)	Size of fund at yr. end	Withdraw	Carry Forward
0		435.5	0	435.5
1	43.6	479.1	100	379.1
2	37.9	417.0	100	317.0
3	31.7	348.7	100	248.7
4	24.9	273.6	100	173.6
5	17.4	190.9	100	90.9
6	9.1	100.0	100	0.0

There are many possible uses for this particular formula in all areas of economic activity.

Example:

Would I be better off buying a car for £12,000, running it for 5 years, and then selling it for £5,000, or leasing the same car for six years at £1,800 pa? Servicing, repairs etc are assumed to be the same for both cases, and the money to finance either would come out of an account yielding 6% pa.

Working out the growth rate of an asset (cont.)

Buy option:

Purchase 12,000.00

Sell in 5 years 5,000.00

Depreciation 7,000.00

PV if £1, 5yrs @ 6% 0.7473

PV of 7,000 5,231.10

NPV of Buy option 5,231.10

Lease option:

Lease cost pa 1,800.00

PV 1 pa, 5 yrs @ 6% 4.2124

PV OF 1,800 pa 7,582.25

PV of lease option 7,582.25

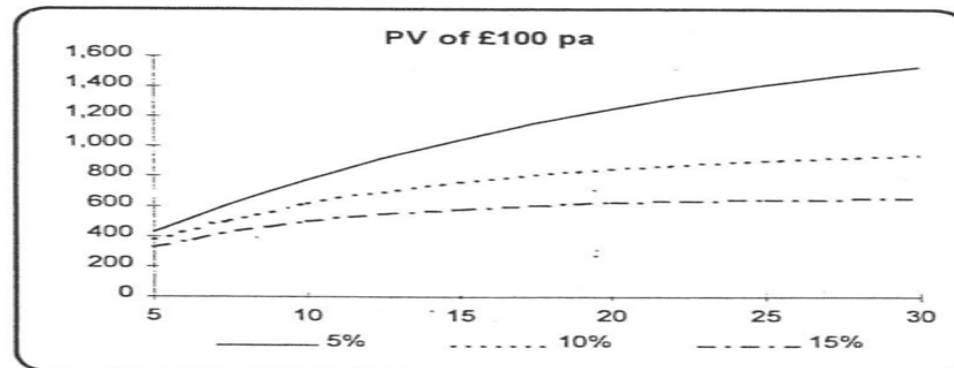
In this example the “buy” option is to be preferred. Always assuming that I had the money to spend in the first place, I could invest £5,231 at 6% which would grow to £7,000 at the end of 5 Years . This could compensate for the depreciation, and put back into the same financial position (i.e. having £1,200) at the end of the period. Too finance the lease payments would require that I invest £7,582 now. The decision rule in this case (where we are dealing with costs) is to choose the option with the lowest PV

Changing the Discount Rate:

Changes in the discount rate can have significant effects upon the present value of a stream of payments or savings. The Present Value of £100 pa saved at 5%, 10% and 15% is as follows:

Years	5%	10%	15%
5	433	379	335
10	772	614	502
15	1,038	761	585
20	1,246	851	626
25	1,409	908	646
30	1,537	943	657

Or graphically:



Changing the Discount Rate:

This is the sort of information that we need to help to make decisions as to how much it is worth' while spending initially in order to secure a flow of savings into the future. Over a 20 year time span it would be worth spending up to £1,246 initially to save £100 pa if interest rates were predicted to be 5% pa, £851 at 10% pa, and £626 at 15% pa. The break even cost of spending to save falls as interest rates rise because at the higher rates of interest it would be more possible to cover the cost of the lost savings out of the proceeds of an invested fund. More practically, if the initial spending was financed out of borrowed money, higher savings would be necessary to cover the interest charges on the borrowed money at higher interest rates.

Changing the number of years.

It can be seen from the above graph that at higher discount rates the gradient of the curve becomes almost flat after 25 or 30 years. The reason for this becomes clear if we look at how the formula works. Where $r = .15$ the expression $(1 + r)^n$ becomes extremely large when the value of n gets past 25. It follows that the reciprocal of this will be extremely small. Taking the argument one step further, if the value of $n = \infty$, then the value of the whole expression will tend towards zero, and the formula as a whole can be reduced to:

$$P = \frac{C}{r}$$

This version of the PV of 1 pa is used in situations where the flow of costs or savings pa is anticipated to carry on *in perpetuity*. Strictly speaking, "perpetuity" means "for ever", but for all practical purposes it can be applied when the flow of costs or savings to be evaluated exceeds 20 + years.

Changing the number of years (cont.)

Example: 1

A shop, let on a long lease at £18,000 rent pa, is being offered for sale at auction. If it was possible for you to obtain a rate of return of 8% pa on alternative investments of similar security, what is the maximum amount that you could afford to bid for the shop?

Method:

Work out the Present Value of the stream of rental payments (capitalise the rent).

$$P = \frac{18,000}{0.08}$$

$$P = £225,000$$

Changing the number of years (cont.)

Under the circumstances, it would not be worth while bidding more than £225,000, as above this amount the annual return of £18,000 would represent a rate of return of less than the 8% obtainable elsewhere.

An alternative way of working through the above calculation would be to calculate the number of years rent it would be possible to pay for the shop in order to achieve a target rate of return of 8% pa. (the Years Purchase). Quite simply, the YP is the reciprocal of the target rate of return:

$$YP = \frac{1}{0.08}$$

$$YP = 12.5$$

In other words, if we were to pay 12.5 * 1 years rent for the shop (in this case £225,000) we would achieve our target rate of return of 8%

Changing the number of years (cont.)

Example 2:

It is possible to buy Government Securities which give a return of perpetuity of £2.50 for every £100 worth held (2 ½% Consoles). The return is paid out in four instalments per year. If interest rates generally were standing at 6% pa, how much would it be worth your while paying for £100 worth of these securities?

Method

Work out the Present value of £100 pa in perpetuity at a discount rate of 6% compounded quarterly .

6% compounded quarterly equates to:

Changing the number of years (cont.)

Formula:

$$\begin{aligned} & [(1+(r/t))^t] - 1 \\ & = [1+(.06/4))^4] - 1 \\ & = 0.06136 \\ & = 6.136\% \text{ annually} \end{aligned}$$

$$P = \frac{2.5}{0.06136}$$

$$P = 39.58$$

The value of £100 worth of 2 ½ % Consols under these circumstances will therefore be £39.58 The same kind of approach can be used to put a value on ordinary shares, but the situation will be made much more complex by the insecurity of the dividend stream and by doubts as to how long it will last.

Dealing with intermittent income streams

There are times when the income or cost streams that we are trying to evaluate change from time to time. These can be dealt with either by treating each year individually (as in a DCF) or by calculating the PV of each block of income or cost, and then bringing the result back to Present Value.

Example:

A firm wishes to move to a new office which it thinks it will need to occupy for the next eleven years. On offer are two possibilities, the rental pattern for each of which is as follows:

- a. Rent of £5,000 pa for the first three years, followed by five years at £6,000, and the remaining three years at £7,000, or
- b. Rent of £4,000 pa for the first two years, followed by £5,500 for the next five years, and the remaining four years at £6,500.

Dealing with intermittent income streams (cont.)

Method:

Discount both options back to Present Value at the firm's cost of capital (say 8% pa).

Method 1 - treating each year separately:

Year	Rent (a)	PV @ 8%
1	5,000	4,630
2	5,000	4,287
3	5,000	3,969
4	6,000	4,410
5	6,000	4,083
6	6,000	3,781
7	6,000	3,501
8	6,000	3,242
9	7,000	3,502
10	7,000	3,242
11	7,000	3,002

Present Values 41,649

Rent (b)	PV @ 8% 3,704
4,000	3,704
4,000	3,429
5,500	4,366
5,500	4,043
5,500	3,743
5,500	3,466
5,500	3,209
6,750	3,647
6,750	3,377
6,750	3,127
6,750	2,895

39,005

Dealing with intermittent income streams (cont.)

Method 2 - PV each block of rent:

- a) PV 1 pa 3yrs @ 8% 2.5771 *5,000 = 12,885 i.e. PV of 1st block at start of yr 1
- b) PV 1 pa 5yrs @ 8% 3.992 *6,000 = 23,958 i.e. PV of second block at start of yr 4
- c) PV 1 pa 3yrs @ 8% 2.5771 *7,000 = 18,039 i.e. PV of third block at start of yr 9

And then bring them all back to year 0

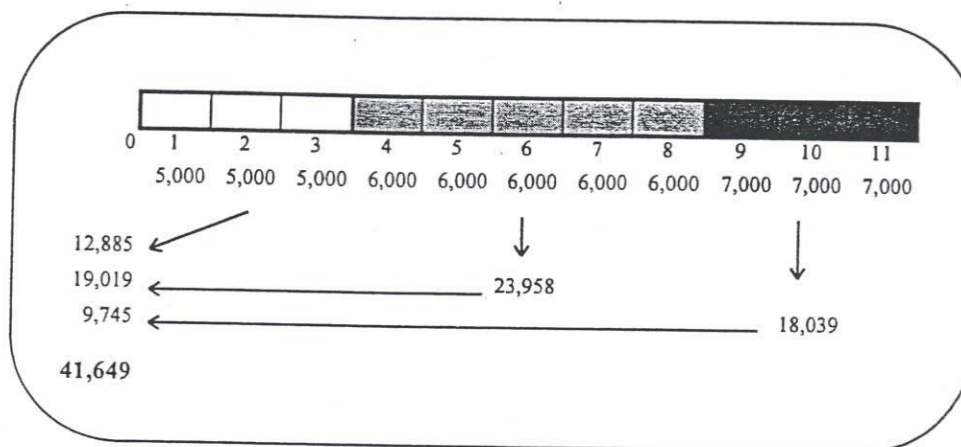
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|------------------|------|--------|---------|----------|
| a) PV of 1, 0yrs | @ 8% | 1.0000 | *12,885 | = 12,885 |
| b) PV of 1, 3yrs | @ 8% | 0.7938 | *23,958 | = 19,019 |
| c) PV of 1, 8yrs | @ 8% | 0.5402 | *18,039 | = 9,745 |

PV of option (a) 41,649

Dealing with intermittent income streams (cont.)

What **Method 2** was doing was to first of all calculate how much it would be necessary to invest at 8% to pay for the rent at the start of each of the three blocks. It then went on to calculate how much we would need to set aside now (yr 0) such that at 8% it would grow to that sum. For example, if we invested £9,745 at 8% it would grow to £18,039 by the end of year 8. This is the sum we would have invested to pay the rent of £7,000 pa for years 9,10 and 11.

Diagrammatically, the process could be represented thus:



Dealing with inflation

In working out the Present Value of a series of identical cash flows over a period of time during which it is expected that prices will rise, one may either adopt the "long" approach and inflate each cash flow before bringing it back to Present Value, or it is possible to adjust the PV of 1 pa formula and do the whole operation in one calculation.

Table A

Year	Cash Flow pa	+ Inflation @ 7%	Discounted @ 10%
0	100	100.00	100.00
1	100	107.00	97.27
2	100	114.49	94.62
3	100	122.50	92.04
4	100	131.08	89.53
5	100	140.26	87.09
6	100	150.07	84.71
7	100	160.58	82.40
8	100	171.82	80.15

Total

807.82

Dealing with inflation (cont.)

- ◆ Table A above shows the longhand approach to the problem. A series of cash flows of £100 per year is first of all adjusted for inflation at 7%, and the resultant figures are then brought back to their Pvs at a discount rate of 10%. The PV of all the cash flows is seen to be £807.82. In practical terms, this shows that if I wished to make an annual expenditure on something whose cost was presently £100, but which was rising by 7% pa, and if interest rates were 10%, then I could make provision for all of the expenditure by investing £807.82 today.
- ◆ As the rate of inflation and the rate of discount are working in opposite directions, it ought to be possible to simply adjust the discount rate to take account of both effects at the same time. Simply subtracting the discount rate from the inflation rate is the obvious thing to do, but this does not work

Dealing with inflation (cont.)

Table B (Check)

Year	Cash Flow pa	Discounted @ 3%
0	100	100.00
1	100	97.09
2	100	94.26
3	100	91.51
4	100	88.85
5	100	86.26
6	100	83.75
7	100	81.31
8	100	78.94

End of Year	Interest (1yr@7%)	Size of fund at end of yr	Withdraw	Carry Forward
0		801.97	100.00	701.97
1	70.2	772.17	107.0	665.17
2	66.5	731.68	114.49	617.19
3	61.7	678.91	122.50	556.41
4	55.6	612.05	131.08	480.97
4				
5	48.1	529.07	140.26	388.81
6	38.9	427.69	150.07	277.62
7	27.8	308.38	160.58	144.80
8	14.5	159.28	171.82	-12.54

If we simply discount at (10% - 7%) 3%, the PV of £801.97 is insufficient to fund the anticipated expenditure.

Dealing with inflation (cont.)

The correct formula to use in these cases is:

$$r_i = [(1+r) / (1+i)] - 1$$

Where:

r_i = the inflation adjusted discount rate

r = the rate of interest / discount

i = the rate of inflation.

Substituting:

$$r_i = [(1.1) / (1.07)] - 1$$

$$r_i = 0.02804$$

$$r_i = 2.8\%$$

Dealing with inflation (cont.)

Testing at this rate:

Table C

Year	Cash Flow pa	Discounted @ 2%
0	100	100.00
1	100	97.27
2	100	94.62
3	100	92.04
4	100	89.53
5	100	87.09
6	100	84.71
7	100	82.40
8	100	80.15

Total 807.82

Check

End of Year	Interest (1 yr @ 7%)	Size of fund at yr end	Withdraw	Carry Forward
0		807.82	100.00	707.82
1	70.8	778.60	107.00	671.60
2	67.2	738.76	114.49	624.27
3	62.4	686.70	122.50	564.19
4	56.4	620.61	131.08	489.53
5	49.0	538.48	140.26	398.23
6	39.8	438.05	150.07	287.98
7	28.8	316.78	160.58	156.20
8	15.6	171.82	171.82	0.00

Dealing with inflation (cont.)

It can be demonstrated that £807.82 is sufficient to pay for a series of 9 cash flows starting immediately and inflating at a constant 7% pa if interest rates are constant at 10% pa in the interim.

If, finally, we substitute the inflation adjusted discount rate into the PV of 1 pa formula, we arrive at the same result.

Formula:

$$P = \left[1 - \frac{1}{[(1+r_i)^n]} \right] \div r_i + 1 * 100$$

Dealing with inflation (cont.)

Note: the addition of + I to the expression to take account of the fact that the first of the cash flows arises immediately, not at the end of the first period as is assumed in the previous versions of the formula.

Substituting

$$P = \left[\frac{1}{1 - \frac{[(1.028)^8] - 1}{.028}} \right] + 1 * 100$$
$$P = 807.93$$

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