‘Rules For Investment Decisions’

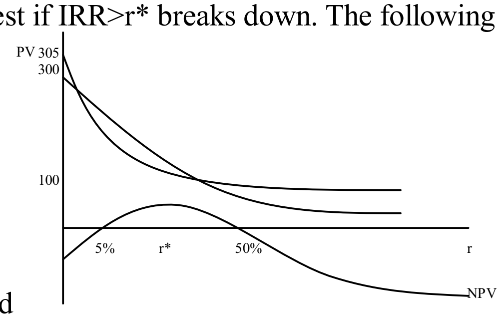
Because of various shortcomings in the average rate of return and payback methods, it is generally felt that discounted cash-flow methods provide a more objective basis for evaluating investment projects. The two discounted cash-flow methods are Internal Rate of Return (IRR) and Net Present Value (NPV). This Technical Note assumes basic concepts and calculations of IRR and NPV are understood but if employees would like further information on these, they are advised to consult *Van Horne, Financial Management and Policy, 11th edition, pg 14-21.*

In most situations, IRR and NPV provide the same choices. ‘The IRR approach has the advantage of providing a rate of return that is easier to interpret, and for that reason is popular in industry.’ (*Schall, 1987, pg202*). The IRR method does, however, have several drawbacks and the NPV method is generally favoured in most textbooks, despite having problems of it’s own. This Note aims to resolve potential inconsistencies between IRR and NPV analysis, and to show the different situations that might apply. The situations we will address involve investment decisions for independent (IP) or mutually exclusive (ME) projects that are with (CR) or without (NCR) capital rationing, enabling us to build an investment appraisal window at the end of the Note to help summarise appropriate investment rules that should be employed for each situation.

Independent Projects with No Capital Rationing - The basic rule for all projects that have ‘normal’ cash flows is to invest if NPV>0 or IRR>r*. But the IRR rule does have its drawbacks:

No IRR: The IRR rule does not work, however, if there is no IRR. If there was no IRR and the company was using the IRR rule it would not invest, when really no IRR indicates ‘the project has a positive NPV at any cost of capital (r*), and a firm should accept it.’ (Levy, 1997, pg195)

Multiple IRRs: The IRR’s 2nd problem is when non-normal cash flows produce multiple IRRs. When a project has multiple IRRs, the basic rule - invest if IRR>r* breaks down. The following non-normal cash flow produces the following graph:



Year	0	1	2
Payments/Receipts	(100)	300	(205)

Now have to use NPV rule as IRR is both > and < r* unless we create an economically ‘true’ IRR (IRR^t) and turn the non-normal cash flow into a normal cash flow. This is achieved by using the cost of capital (r*) to discount Irregular values back, essentially considering their present values as part of the initial investment. This leaves just one IRR - IRR^t, see *Appendix 1* for the working out of IRR^t of the above example. We now have a new rule – for a non-normal cash flow series, invest if IRR^t>r*.

Mutually Exclusive Projects with No Capital Rationing - When using NPV to make investment decisions the simple rule to follow is to invest in the project with the highest NPV, as this will increase shareholder wealth by the largest amount. If it is possible to repeat mutually exclusive projects, however, then this rule might be wrong. If we had two projects – a 4-year project and a 5 year project and the terminal year for both projects was in 20 years then either the comparison should be based on cash flows over the years up to the common terminal year or an equivalent annuity series for each project should be calculated and compared.

Standardised IRR Average: If IRR is to be used to rank ME projects, then there must be a common terminal date – i.e. an average IRR for each project must be found. To work out the average IRR you have to compound each receipt to the terminal year to give its value in the future; combine the compounded forward values to give the total terminal value and then find the IRR that makes the discounted total terminal value equal to the investment. If the IRR is used to rank ME projects, however, there must also be standardisation to a ‘common’ level of investment in each mutually exclusive project. For example, if a firm were looking into investing into two projects – A and B, with a cost of capital (r*) of 8%, the following would have to be done assuming ‘reinvestment’ of the cash flow proceeds at r*:

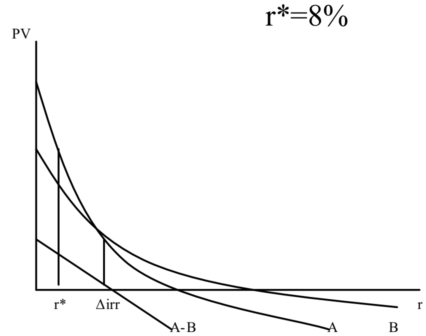
If Project A costs £100m and has a Yield IRR^{AV} of 15.5% for 4 years.
And Project B costs £90m and has a Yield IRR^{AV} of 15% for 4 years.

Then Standardised IRR^{AV} ($SIRR^{AV}$) of B=(0.9 x 15)+(0.1 x 8)=14.3%. Project A is chosen as a result. We can therefore use the rule for NCR and ME projects to invest choosing the project with the highest SIRR AV based on a ‘common’ investment size and common terminal date. For the $SIRR^{AV}$ comparison to compare with the choosing the highest NPV for selecting mutually exclusive projects, it doesn’t matter which is used, because the key requirement is the ‘common’ level of investment.

Incremental IRR test: Another way of checking the selection of ME projects is correct is through the use of an Incremental IRR(IIRR) test. This is best shown using a worked example:

r*=8%

Year	0	1	2	3	4	NPV
A	(100)				180	32.3
B	(90)		120			12.84
A-B	(10)		(120)		180	19.46



Incremental IRR is greater than r* so choose project A. This again agrees with the highest NPV rule and therefore we can also use the test to produce the following rule: Given A has the highest IRR, invest if the ΔIRR of B-A is >or< r*. There is, however, a disadvantage with this rule in that it assumes ‘normal’ cash flows, i.e. no multiple IRR’s. This is known as ‘tricky’ incremental IRR and leads to intersection at positive and negative NPVs. We need, therefore, to use the more general test using the true IRR or the IRR^{AV} as appropriate and testing whether IIRR is >or< IRR^{A} and IRR^{B}. If less than, you use the intersection at positive NPVs; if greater than, you use the intersection at negative NPVs.

Multiple solutions make the Incremental IRR test a less appropriate method to use. The solution to this problem is to consider the appropriate ‘investment base’ for the incremental cash flow series and use the $SIRR^{AV}$. The standard weighting average approach, however, also has it’s problems as in many instances it is seen as biased because it doesn’t uses weights at the terminal dates and therefore might give the wrong decision compared with the NPV rule which, as *Haim Levy, Principles of Corporate Finance,Chapter 5* shows, ‘is superior as it maximises the stockholders’ wealth.’

Independent Projects with Capital Rationing – In situations where firms do not have unlimited capital it is essential to rank all the available projects to the firm in terms of the value of the projects to the firm. Assuming there is no time dependency, then firms will go ahead with the highest ranked projects in order until all capital is exhausted.

Average IRR – As with projects which are ME and have NCR, when assessing projects with different terminal dates, the calculation of IRR^{AV} ensures that shorter projects are not overlooked and released capital can be re-invested at r*. So we can therefore use the rule that when choosing IP projects with CR firms should rank using IRR^{AV} with a common terminal date.

Intersecting NPV and NPV/c Curves – In order to maximise the total NPV from the capital available to the firm, it is necessary to show how much NPV per scarce capital resource each project produces. Therefore, firms rank using each project's NPV/C choosing the highest downwards until the capital budget is exhausted. Project IRRs cannot be used because of intersecting NPV or NPV/C curves, which contradict the NPV rule and lead to choosing the wrong project.

Non-Time & Time Dependent Projects – Where some or all of the projects are time dependent, firms have to analyse the Opportunity Cost (OC) of not selecting a project. The OC of deferring a time dependent project is larger than the OC of a non-time dependent project as it can be done in the following year unlike the time-dependent projects.
The opportunity cost of deferral is: [1 – 1/(1+ r*)].
This reflects the discounting that is required for postponing the project for one-year. Therefore, NPV = [1 – 1/ (1+ r*)] = OC. As we use NPV/C to rank independent projects,
NPV/C = [1 – 1/(1+ r*)] = OC/C (Opportunity Cost / Capital).

Therefore, for non-time dependent projects we rank using OC/C or NPV/C to reflect opportunity cost of deferral but only use OC /C if combining with time dependent projects. For an example of this see *Appendix 2*. For time dependent projects, however, we only use the NPV/C ranking.

Mutually Exclusive Projects with Capital Rationing – In the cases of non-time dependent projects, programming solutions are often used to solve investment decisions. The details of which are not covered in this Note, so employees are advised to research this area, looking at linear programmes and primal and dual formulations in particular, if they wish to further their knowledge on this area.

Time Dependent Projects – The gains of bringing in a completely new project may in fact be less than the benefits of bringing in an incremental project and this, therefore should be accounted for when ranking time dependent ME projects with CR. For example:

Project	Cost	NPV	NPV/C	ΔNPV/ΔC
A	100	40	0.4	
B	110	41	0.373	B/A=0.1
C	130	46	0.354	C/B=0.13 C/A=0.2
D	160	47	0.294	D/C=0.03 D/B=0.12 D/A=0.17
E	190	40	0.211	E/D= -0.23 E/C=-0.1 E/B=-0.01 E/A=0

If the firm had no capital rationing, it would use the highest NPV rule and go ahead with project D. If the firm had capital rationing, it would use the NPV/C rule and go ahead with project A. But in this particular instance, project C has the highest incremental rise so,
In the above example, the first £100 can be spent on project A @ 0.4 = 40NPV. The next stage is to find the project with the highest NPV – in this case project C. This can be considered as an incremental investment showing that an extra £30 spent @ 0.2 will increase NPV by 6. This means that if the budget was £130, firms would choose project A plus project C/A which equals project C. If the budget, however, was even moree relaxed then firm's would ideally be able to choose project D as this has the highest NPV and will therefore increase shareholder wealth the most.

It is therefore of utmost importance that firms rank projects using NPV/C plus ΔNPV/ΔC to avoid exclusion of incremental projects. They can be combined with IP project ranking lists.

Investment Appraisal Window

Every rule highlighted in the Note so far can be summarised in the following table. Employees are advised to consult this table when making investment decisions in the future in order to make the best possible investment decision.

	NCR	CR	
		Non-Time Dependent	Time Dependent
IP	NPV > 0 IRR > r* (Normal Cash Flow) IRR^t > r* (Non-Normal Cash Flow)	Rank using OC/C or NPV/C to reflect opp cost of deferral but only use OC /C if combining with time dependent projects	Rank using IRR^{AV} with a common terminal date. NPV/C ranking takes account of opp cost of no deferral.
ME	Highest NPV Highest $SIRR^{AV}$ based on a 'common' investment size and common terminal date Or use Incremental IRR test: Given A has the highest IRR, invest if the ΔIRR of B-A is >or< r*. If 'tricky', use IRR^{AV} or IRR^t as appropriate and note whether IIRR is >or< IRR^A and IRR^B	Programming Solutions	Rank projects using NPV/C plus ΔNPV/ΔC to avoid exclusion of incremental projects. They can be combined with IP project ranking lists

Conclusion

In most situations, the same choices are provided where the NPV is used and where the IRR method is properly applied using the above rules. The IRR approach has the advantage of providing a rate of return that is easy to interpret and is therefore so popular within industry. 'In the case of conventional projects (normal cash flows) that are independent of eah other, both NPV and IRR rules will lead to the same accept/reject decisions.' (*Drury,2000, pg466)*. In cases where there are non-normal cash flows, the IRR method has to be changed and in some cases may not produce accurate results. The NPV rule can, however, be used in the case of non-normal cash flows. The NPV and the IRR rules also sometimes provide different project rankings when investment decisions are being made with capital rationing. This is mainly down to the time value of money. In discounting the project's cash flows, both rules consider the time value of money. However, the rules' reinvestment assumptions consider the time value of money differently, and this is one way in which differences in project ranking may result. 'The NPV rule assumes that re-investment of the project's interim cash flows are at the cost of capital, whereas the IRR rule assumes reinvestment at the project's IRR' (*Levy, 1997, pg191*). The NPV rule also takes into account the scale of investment whereas the IRR rule doesn't.

Overall, it is the judgement of many text books and experts that NPV rules are superior to IRR rules as a capital budgeting approach. Any problem that can be treated with IRR can also be analysed using present value, whereas the reverse is not the case. In Appendix 8A in Schall, Haley& Schachter's *Introduction to Financial Management*, a study is undertaken proving why an investment's net present value equals its benefit to current stockholders. Surely then, this is as good an indicator as any to suggest that the NPV rule is the best guide to selecting investments.

Appendix 1

$-100 - 205/(1+r^*)^2 = -300/(1+irr)^1$

Given a cost of capital of 10%, this yields:

$-100 - 205/(1.1)^2 = -300/(1+irr)^1$

where $-100 - 205/1.21 = -100 - 169.42 = -269.42$

therefore $IRR^t = -300/-269.42 - 1 = 0.111$ or 11.1%

Appendix 2

Time Dependent Projects – therefore use NPV/C not OC/C because they are not non-time dependent.

	Cost	NPV	NPV/C	Ranking
A	80	20	0.25	3
B	60	10	0.17	4
C	70	30	0.43	1
D	40	15	0.38	2

Therefore if these projects are independent we will produce C, then D, then A, then B depending on the capital constraints.

Bibliography

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