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Why IRR is not the right measure for return analysis and What's then?

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ABSTRACT

Literature reviews by the author on capital budgeting techniques weighting on the use of NPV andIRR shows that using IRR without certain cautions has an inconsistency. It has something to do with the rules of thumb about using NPV and IRR. Recall that IRR is useful when it has an external comparison such as a hurdle rate. Even then, both rates are mutually exclusive. Cashflowsequence turned out also affecting how IRR calculation would get us. Extended attempts using illustrative situations with sensitivity analysis exhibit influence of each parameter to the IRR result. This paper is intended to re-summarize already existing papers that using NPV and IRR should be followed by understanding their weaknesses. Its correlation in civil engineering works isfor feasibility analyst team to know limitations at situations that needs consideration before takingconclusions from applying the techniques.
Keywords: NPV, IRR, investment evaluation criteria, sensitivity analysis, decision making, output interpretation

1. Introduction

The theory and practice of corporate finance: Evidence from the field, a financial and economic journal in 2001, published a paper by Graham and Harvey titled "How do CFOs make capital budgeting and capital structure decisions. The paper shows that NPV and IRR are the dominant factors (among others *i.e.*, accounting rate of return, payback period and profitability) used in capital budgeting methods. Studies done by the author of this paper through sensitivity analysis, NPV vs IRR comparisons reveal some situations of outputs that can mislead interpretations from the use of IRR without knowing their weaknesses. This paper intends to reiterate discussions about limitations in using NPV and IRR for better interpretation in investments evaluations.

IRR can be theoretically defined as a compounded rate of an amount of capital obtained (which normally on an annual basis) from lending it to be used to run a project. The IRR rules referred from Levy et. al in 1978 in their book, "Capital investment and financial decisions" say: accept projects with IRR> hurdle rate and reject otherwise. The NPV rules say: accept projects with NPV>1 and reject otherwise. Another statement referred from Crean et. al. in 2013 ("Gross" present value and "external" rate of return: An alternative pedagogy for teaching discounted cash flow analysis) implies that while IRR is the rate for NPV = 0, a specific regard to IRR rules above, we can only tell an IRR is good or bad when it has a comparison to a hurdle rate (which is basically cost opportunity of a capital) or another external interest rate. Another reading titled Corporate Finance in 2014 from Berk and DeMarzo even reads that the external comparison must have: same investment value; same investment period and same risk level profile.

2. Cashflow sequence

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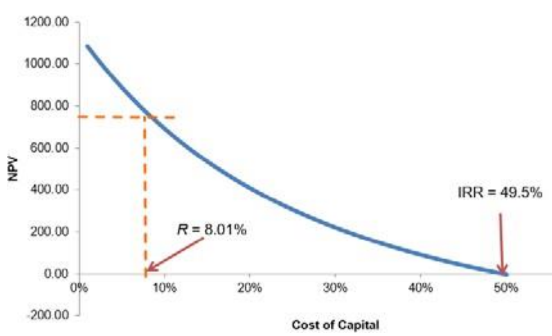
An IRR in many references is defined as a discount rate for a set of cashflow with zero NPV boundary condition. In other words, it is the level of hurdle rate that would tell how much it is our cashflow forecast would give us a return in a zero net present value. Seitz *et al*. in their book of "Capital Budgeting andLong-Term Financing Decisions. Alternate Measures of Capital Investment Desirability" part two chapter six implies that; A conventional capital investment requires cash outlays before any cash inflows are received and has cumulative cash flows that change from negative to positive only once. In a graphical explanation, an internal rate of return is the discount rate at the point when the line crosses the horizontal axis – the pointat which the net present value is zero.

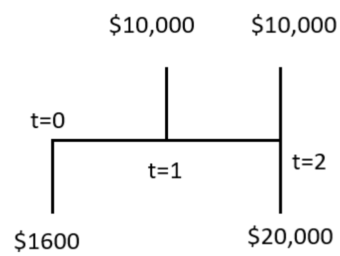
$$\mathrm{NPV} = \mathrm{CF}_0 + \frac{\mathrm{CF}_1}{(1+\mathrm{IRR})^1} + \frac{\mathrm{CF}_2}{(1+\mathrm{IRR})^2} + \cdots + \frac{\mathrm{CF}_N}{(1+\mathrm{IRR})^N} = 0$$

Numerically, we can solve the equation above using trial & error or goal seek with excel spreadsheet or other higher order polynomial solver. A review shows that IRR rule may coincide with NPV rule whenever a sequence of negative cashflow precede all series of positive cashflows.



Source: Own calculation
Fig-1. NPV rules coincide with IRR rules

The higher the inputted cashflow would obviously get us higher IRR. Yet things will come differently when a negative cashflow or a series of negative cashflow comes: (a) after a positive cashflow or a series of positive cashflow; (b) in between positive cashflow or a series of positive cashflow. IRR with such features may happen in reality for example: a project that got funding components or liabilities which regarded as negative cashflow even after a single positive cashflow has been accounted. It will end up with square root of negative 1, or multiple results which both are too difficult to digest financially. Therefore, in this case NPV rules will not coincide IRR rules.



Source: Barbieri et. al. 2007, Internal Rate of Return: A Project Parameter, not a Measure for Investment Return.
Illustrative-1. A negative CF after A positive CF. A solution with a quadratic equation for solving IRR will get us $\mathrm{IRR}_1 = 0.25$ and $\mathrm{IRR}_2 = 400$

This adds to an already understanding that IRR is limited to internal interest of an organization that is using it, yet it needs an external comparation (a discounted rate which is applied elsewhere) in order to be concluded.

3. Too much gap for uncertainty

Too high NPV and in this case too high IRR can drive us overconfident. Did we estimate our thing on the high end, or we were otherwise excessively prudent? In reality, those attributes are the determinant drives for many financial managers and decision makers. Their experience, knowledge and decisive level of confidence for numerical judgements, can lead them to be too optimistic especially when it comes to forecasts.

We can possibly compare two things and feel confident when the comparison gives us a sensible outlook. As an example, this paper uses an illustrative investment analysis of a girder producer project for company X with details figured in Fig-2.

Cost of Capital	8.01%
Initial Investment ($mil)	250.0
PP&E Liquidation Value	50%
PP&E Life for Depreciation	5.00
Initial Market Size (Units Mil)	0.80
Market Growth Rate	30%
Initial Market Share	15.00%
Market Share Growth Rate	20.00%
Initial Unit Price ($/unit)	12,000
Bi-Annual Price Increases ($/unit)	300.00
Tax Rate	25.45%
COGS / Sales (% Sales)	80.66%

Source: Own calculation
Fig-2. An ilustrative budgeting

After adding other accounting parameters (such taxes etc. not shown on the table) and performing the NPV – IRR calculation, we got NPV of 763 and IRR of 49.45%. Let us now take a look again at Fig-1. Assuming a hurdle rate being used for a proposed project is a little over than 8%. At a certain cashflow series, turned out the IRR is 49.5%. The obtained IRR is nearly four times the applied hurdle rate at about 12% which gives us a considerable gap difference.

The obtained IRR by value is obviously good and the conclusion according to IRR rules is: Take the project. Our common sense however, might tell us this is too good to be true, but what if it is something we could expect. An investment package is not a homogeneous solid material with homogeneous properties. So, with gap about 41 points, it leaves us too much room of uncertainties. There has to be a certain element within the bundled investment we need to pay more attention to.

4. Sensitivity Analysis

One way to measure it is by using sensitivity analysis. The idea is to measure the driving factors though it may not be an ideal way. It is not ideal because the simplified sensitivity analysis is set up to measure every single factor independently holding fix all other factors. Though it is not a perfect solution, we can at least grab some senses of what is going on and why the IRR 49.5% came out at such magnitude.

4.1 Breakeven analysis

Let us start with breakeven analysis. This is basically to bring every single cashflow parameter included in the package consecutively to NPV zero assuming nothing happen to the other parameter while we tie one cashflow parameter to NPV zero. Say the initial investment of the project is $ 250 mil. Applying the assumed hurdle rate of 8.1% individually to the value, it will get breakeven at $ 983.1 mil.

If we look at PP&E (property, plant & equipment) liquidation value that is far below zero and interpreted as if the situation is totally destructive and thus regarded as ignorable. Not even after every cashflow parameter is brought to NPV zero, we can notice some parameters are just reasonably different values from their initial values (before brought back to NPV zero). These values could actually be the parameters we need to pay more attention to if we are about to do more thorough financial analysis. The others result in large difference. It is fair to say those parameters showing significant gap different are the ones with potential bias and could be the reason why we get such a big different between our IRR and hurdle rate.

To this point conclusion in regard to sensitivity analysis, breakeven analysis can give us partial review on each parameter potential bias. Though it is good, we still need more analysis to support this result.

	Cost of Capital	Initial Investment ($mil)	PP&E Liquidation Value	PP&E Life for Depreciation
Base	8.01%	250	0.500	5.000
BE	49.48%	983.09	(18.339)	0.410

	Initial Market Size (Units Mil)	Market Growth Rate	Initial Market Share	Market Share Growth Rate
Base	0.80	0.3	0.150	0.200
BE	0.417	(0.392)	0.078	(0.129)

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	Initial Unit Price ($/unit)	Bi-Annual Price Increases ($/unit)	Tax Rate	COGS / Sales (% Sales)
Base	12000	300.000	0.255	0.807
BE	6118.177	(5927.763)	0.905	0.898

Source: Own calculation

Fig-3. Parameters with breakeven analysis. Here some parameters show large difference while some others show reasonable difference at NPV zero. (*BE= Breakeven*)

4.2 Comparative statics

Earlier, we mention we can only tell an IRR is good or bad by comparing to another hurdle rate. What if we put two more comparative hurdle rates (r_1 & r_2) just to see how much different each parameter would turn out? Using the same NPV zero method, we can use say 10% upper and lower; and bring back all to NPV zero. We can then average the value changes with respect to hurdle rates difference to see an Elasticity Coefficient of each parameter.

With breakeven analysis, it is hard to set how much different is reasonable or too much. Doing it with more hurdle rates as comparison while implementing the same basic assumption of mutually exclusive parameters, this is to measure reaction consistency of each parameter to different hurdle rates. Some parameters such Initial market size, Initial market share and COGS (Cost of Goods Sales) with absolute elasticity coefficients are considered bigger than others, in this illustration as shown in Fig-4.; there still questions of why elasticity coefficients are relatively inconsistent with breakeven analysis.

A tentative hypothesis to this point remains the same. Though the higher the absolute coefficient value means less bias, the elasticity of overall IRR with respect to each parameter as part of sensitivity analysis still holds all parameters constant while doing an analysis to one of them.

	hurdle rate			Elasticity
Cost of Capital	7.21%	8.01%	8.82%	
	794.30	763.00	732.83	-0.40
Initial Investment ($mil)	225.0	250.0	275.0	
	789.02	763.00	736.98	-0.34
PP&E Liquidation Value	45%	50%	55%	
	760.97	763.00	765.02	0.03
PP&E Life for Depreciation	4.50	5.00	5.50	
	755.41	763.00	769.20	0.09
Initial Market Size (Milion)	0.72	0.80	0.88	
	603.66	763.00	922.34	2.09
Market Growth Rate	27%	30%	33%	
	729.06	763.00	797.01	0.45
Initial Market Share	13.50%	15.00%	16.50%	
	603.66	763.00	922.34	2.09
Market Share Growth Rate	18.00%	20.00%	22.00%	
	702.18	763.00	825.99	0.81
Initial Unit Price ($/unit)	10,800	12,000	13,200	
	607.33	763.00	918.66	2.04
Bi-Annual Price Increases ($/unit)	270.00	300.00	330.00	
	759.32	763.00	766.67	0.05
Tax Rate	23%	25.45%	28.00%	
	792.85	763.00	733.15	-0.39
COGS / Sales (% Sales)	72.59%	80.66%	88.73%	
	1436.86	763.00	89.13	-8.83

Source: Own calculation

Fig-4. Parameters with values elasticity closer to zero tend to be bias in this illustration.

4.3 Scenario analysis

So far in breakeven and elasticity analysis we can see a relative insight of influence of each parameter with NPV zero. Another attempt we can try now is to compare one parameter to another in this package. Noted from Fig-1 that our illustration has the maximum NPV at applied hurdle rate zero, in this case is $1137.69. The analysis uses data table solver from excel to extrapolate various NPV values with regard to the intended parameters. After comparing parameters tied to NPV zero, this time is basically NPV against NPV for two different parameters holding the rest parameters fix.

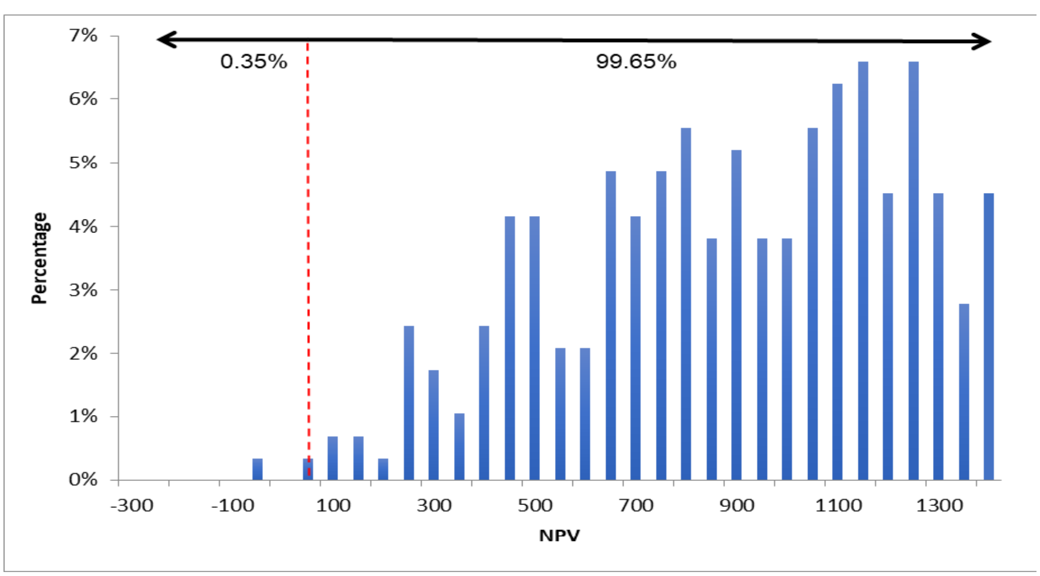
Let say we want to see how much changes in NPV if we compare changes in initial market share to changes in unit price. We are not discussing the yellow-colored cells at Fig-6 until Fig-9. The yellow-colored cells are those with NPV larger than 1137.69 which thus they are applying negative hurdle rates or simply negative NPV. Here we can take a look that initial price could be as low as $9500, it still turns a positive NPV at $151.60 though with lower projected initial market share at 11.61%. Plotting the NPV 151.6 at Fig-1 will give us a rate about 34.73%, which is still acceptable and less rate gap to reduce room of uncertainty. This output seems agreeing with one from breakeven analysis at Fig-3. The breakeven value for initial price is about $6118,177. Also, another conformity with previous hypothesis on elasticity coefficient for far enough from zero, this parameter can be key driving parameter in this investment. A quick say from this point: the initial planned unit price at $12,000 may be too expensive. Yet, that is why we do this analysis, to see and evaluate the standing position of our budgeting model.

Other interesting comparisons are price increase parameter against COGS parameter and initial price versus price increase as figured at Fig-7 and Fig-8. Here shown quite narrow option window for COGS with respect to price increase. It basically shows the balance between production cost and selling price. The cost cannot be too high or too low even with certain price increase or decrease to keep NPV positive at normal interest rate greater than zero. Similar to Fig-7 and Fig-8, Fig-9 actually shows the upper and lower limit of applied hurdle rate in regards of sales to keep positive NPV. Another clue here is that a maximum NPV of 1137.69 should not be relevant anymore if we change the hurdle rate. The profile at graph at Fig-1, would change for different hurdle rate.

More extended similar comparisons could be carried out for different parameters. The analysis could give us a range of exposure in terms of NPV of such to know at least what is the maximum possible initial price to keep NPV positive at certain hurdle rates.

After repeating the simulation above for 500 times, it concludes the positive NPV for this simulation looks very promising as figured at Fig-5. This graph is not an ideal figure (since this is a simplified simulation) and for sure it rarely occurs in reality, unless, the assumptions accommodated in the model is too prudent. In this case, one way we can sense that is from the overprice setting for the initial price.

The comparison attempts done in this paper so far is investigating NPV changes if a parameter is against another parameter. It is very interesting to perform multi-variate comparisons analysis involving probabilistic methods and normal distribution of cashflows to add robustness in setting up the parameters. More analysis such scenario analysis, VAR (value-at-risk), stress-testing are also useful to add on further IRR analysis.



(*Source: own calculation*)
Fig-5. Positive NPV opportunity for company X illustrative simulation.

Price					Initial Market Share						
763	11.61%	12.22%	12.86%	13.54%	14.25%	15%	16.20%	17.50%	18.90%	20.41%	22.04%
14,500	653.48	731.58	813.79	900.32	991.41	1087.30	1240.72	1406.41	1585.35	1778.61	1987.33
14,000	603.29	678.75	758.18	841.79	929.80	1022.44	1170.67	1330.75	1503.65	1690.37	1892.03
13,500	553.10	625.92	702.57	783.25	868.18	957.58	1100.62	1255.10	1421.94	1602.13	1796.73
13,000	502.91	573.09	646.96	724.71	806.56	892.72	1030.57	1179.45	1340.23	1513.89	1701.43
12,500	452.73	520.26	591.35	666.18	744.94	827.86	960.52	1103.79	1258.53	1425.64	1606.13
12,000	402.54	467.43	535.74	607.64	683.33	763.00	890.47	1028.14	1176.82	1337.40	1510.83
11,500	352.35	414.60	480.13	549.10	621.71	698.14	820.42	952.49	1095.12	1249.16	1415.53
11,000	302.16	361.77	424.52	490.57	560.09	633.28	750.37	876.83	1013.41	1160.92	1320.22
10,500	251.97	308.94	368.91	432.03	498.47	568.41	680.32	801.18	931.71	1072.68	1224.92
10,000	201.79	256.11	313.30	373.49	436.86	503.55	610.27	725.53	850.00	984.43	1129.62
9,500	151.60	203.28	257.69	314.96	375.24	438.69	540.22	649.87	768.30	896.19	1034.32

(*Source: own calculation*)

Fig-6. NPV changes with regard to Initial market share parameter vs Price parameter

COGS					Price Increase						
763	133.11	156.60	184.24	216.75	255.00	300.00	315.00	330.75	347.29	364.65	382.88
1.06	-1318.25	-1319.28	-1320.50	-1321.93	-1323.62	-1325.60	-1326.26	-1326.96	-1327.69	-1328.45	-1329.26
1.01	-906.09	-906.34	-906.64	-906.99	-907.40	-907.88	-908.05	-908.21	-908.39	-908.58	-908.78
0.96	-493.93	-493.40	-492.77	-492.04	-491.18	-490.16	-489.83	-489.47	-489.10	-488.71	-488.29
0.91	-81.77	-80.46	-78.91	-77.10	-74.96	-72.44	-71.61	-70.73	-69.80	-68.83	-67.81
0.86	330.39	332.49	334.95	337.85	341.26	345.28	346.61	348.02	349.49	351.04	352.67
0.81	742.55	745.43	748.81	752.80	757.48	763.00	764.83	766.76	768.79	770.92	773.15
0.76	1154.71	1158.37	1162.68	1167.74	1173.70	1180.72	1183.05	1185.51	1188.09	1190.79	1193.63
0.71	1566.87	1571.31	1576.54	1582.69	1589.92	1598.44	1601.27	1604.25	1607.38	1610.67	1614.11
0.66	1979.03	1984.25	1990.40	1997.63	2006.14	2016.16	2019.49	2023.00	2026.68	2030.54	2034.60
0.61	2391.19	2397.20	2404.26	2412.58	2422.37	2433.88	2437.71	2441.74	2445.97	2450.41	2455.08
0.56	2803.35	2810.14	2818.13	2827.53	2838.59	2851.60	2855.93	2860.49	2865.27	2870.29	2875.56

(*Source: own calculation*)

Fig-7. NPV changes with regard to price increase parameter vs COGS parameter

price					Price Increase						
763	133.11	156.60	184.24	216.75	255.00	300.00	315.00	330.75	347.29	364.65	382.88
15,315	1172.62	1175.50	1178.89	1182.87	1187.56	1193.07	1194.91	1196.84	1198.86	1200.99	1203.23
14,586	1078.02	1080.90	1084.28	1088.27	1092.95	1098.46	1100.30	1102.23	1104.26	1106.39	1108.62
13,892	987.92	990.80	994.18	998.16	1002.85	1008.36	1010.20	1012.13	1014.16	1016.28	1018.52
13,230	902.11	904.98	908.37	912.35	917.04	922.55	924.39	926.32	928.35	930.47	932.71
12,600	820.38	823.26	826.65	830.63	835.32	840.83	842.67	844.60	846.62	848.75	850.98
12,000	742.55	745.43	748.81	752.80	757.48	763.00	764.83	766.76	768.79	770.92	773.15
10,200	509.05	511.93	515.32	519.30	523.99	529.50	531.34	533.27	535.29	537.42	539.65
8,670	310.58	313.46	316.84	320.83	325.51	331.03	332.86	334.79	336.82	338.95	341.18
7,370	141.88	144.75	148.14	152.12	156.81	162.32	164.16	166.09	168.12	170.24	172.48
6,264	-1.52	1.36	4.74	8.73	13.41	18.93	20.76	22.69	24.72	26.85	29.08
5,324	-123.41	-120.53	-117.14	-113.16	-108.47	-102.96	-101.12	-99.19	-97.17	-95.04	-92.81

(*Source: own calculation*)

Fig-8. NPV changes with regard to Initial price parameter vs Price increase parameter

rate					COGS						
763	69.27%	71.41%	73.62%	75.89%	78.24%	80.66%	82.27%	83.92%	85.60%	87.31%	89.06%
29.76%	737.17	640.43	540.69	437.87	331.87	222.59	149.73	75.42	-0.38	-77.69	-156.55
22.89%	958.33	842.99	724.08	601.50	475.12	344.84	257.98	169.39	79.02	-13.15	-107.16
17.61%	1174.18	1040.69	903.07	761.20	614.94	464.15	363.63	261.10	156.51	49.84	-58.97
13.54%	1375.75	1225.31	1070.22	910.33	745.50	575.56	462.28	346.72	228.86	108.63	-13.99
10.42%	1557.02	1391.33	1220.52	1044.43	862.89	675.74	550.97	423.70	293.89	161.49	26.43
8.01%	1714.94	1535.97	1351.46	1161.25	965.16	763.00	628.22	490.75	350.54	207.51	61.63
6.81%	1800.74	1614.55	1422.61	1224.72	1020.72	810.40	670.19	527.18	381.31	232.52	80.75
5.79%	1877.60	1684.94	1486.33	1281.57	1070.48	852.86	707.79	559.80	408.86	254.91	97.87
4.92%	1945.93	1747.53	1542.99	1332.12	1114.73	890.62	741.21	588.81	433.37	274.81	113.09
4.18%	2006.31	1802.83	1593.05	1376.78	1153.82	923.97	770.73	614.44	455.01	292.40	126.53
3.56%	2059.37	1851.41	1637.03	1416.02	1188.17	953.28	796.68	636.95	474.03	307.84	138.34

(*Source: own calculation*)

Fig-9. NPV changes with regard to hurdle parameter vs COGS parameter

5. Comparing two different proposals

A suggested earlier in the introduction, that an IRR needs another external IRR for comparison in order to be taken as a conclusion. This time we are simulating two different proposals which are similar to each other only with different cashflow terms. Illustrations below are simplified and could be irrelevant in real life in the sense that they disregard detail financial situations within the company assuming the project is the only one.

For an illustrative purpose, let say the company X is considering a purchase of their production machines in their warehouse for production optimization. There came an offer from supplier A for the machine with anoffer as much as $1.2 mil all in advance thatcould generate production cost saving as much as $390 thousand over the next 5 years.It turned out the IRR is 19% and NPV $330.7thousand. According to IRR and NPV rules, those are good numbers. But is it a good bet?Do we have something else better or just thisis it?

	r	8%						IRR	NPV
		0	1	2	3	4	5		
Case 1	cost A	-1200	390	390	390	390	390	19%	330.70

Source: author
Illustrative-2: Case 1.

So let us say, after sometime of vacuum response, supplier A came back with a new offer. The offer contains the same cost saving feature with a different payment scheme. The new payment scheme came with $400 thousand upfront and $250 thousand spread over 5 years.

	r	8%						IRR	NPV
		0	1	2	3	4	5		
Case 1	cost A	-1200	390	390	390	390	390	19%	330.70
Case 2	Cost A1	-400	-250	-250	-250	-250	-250		
	Saving A1	0	390	390	390	390	390		
	Actual A1	-400	140	140	140	140	140	22%	147.20

Source: author
Illustrative-3: Case 1 and case 2.

It turned out the second offer has 22% IRR which is higher than the first one. The new offer NPV however, is only $147.2 thousand, less than a half of the first offer.

Well, which offer should it take now? To address this, we may take a look again at payment schemes offered by supplier A. From the ($. thousand) 1200 upfront to ($. thousand) 400, there is a different as much as ($. thousand) 800 with a likely implicit loan scheme from supplier A. Let us plot the cashflow line:

	r	8%						IRR	NPV
		0	1	2	3	4	5		
Case 1	cost A	-1200	390	390	390	390	390	19%	330.70
Case 2	Cost A1	-400	-250	-250	-250	-250	-250		
	Saving A1	0	390	390	390	390	390		
	Actual A1	-400	140	140	140	140	140	22%	147.20
	Implicit Loan from A1	800	-250	-250	-250	-250	-250	17%	

Source: author
Illustrative-4: Proposals with different cashflow schemes.

The new offer shows that basically supplier A is lending money to company X with rate at 17%. Which means the opportunity cost of capital by taking the new offer is slightly lower than its initial offer with rate at 19%. So, another clue, IRR seems to disregard scale, even with a proper cashflow sequence.

To add another consideration, let us get another illustrative. We have repeated many times that IRR analysis above holds other variables fixed. Basically, in this case we also hold an assumption that the compoundedrate will occur fix or the term is that the rate is compounded once on an annual basis. That does not sound very ideal after knowing the potential uncertainties from the rate gap at Fig-1. Another illustrative to this case is below.

Company B is paying a loan of $10K with a rate of 10% in the end of an annual period. So, in the end of the loan period, Company B will pay in total (including interest) of $11K. Meanwhile, Company C that took the same

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amount of loan with company B, does it with a different payment scheme. It pays quarterly $250 and in the end of the scheme period, it will pay $10,25K. Question: which one is safer in terms of budgeting?

The payment recaps from both companies look the same and numerically correct. The difference is that anything could happen within a year period. It depends on the standing positions to take the assumption either a view-point as in this case the lender or the borrower. When it comes to compounded and uncompounded rates, the rate to be used in a budgeting analysis shall be defined as how many times it is compounded. The hurdle rate being usually assumed is an effective annual rate. Effective annual rate (EAR) or elsewhere it is called APY (Annual Percentage Yield) is defined from an uncompounded rate with considering compounding periods frequency.

$EAR = (1+ i)^k - 1$; where i is the uncompounded rate; and k is the number of compounding period. A contractual interest loan is usually charged on a semi-annual or a quarterly basis. The scheme by company B is using the annual interest of 10% and compounded once. While the scheme by company C is simply using an annual rate of 10% which is compounded four times. Itdoes not lead to significant different in this case, yet it may be quite considerable amountfor more compounding periods with larger involved capital. The actual annual rate, however is not going to be the same for company B and company C. The actual annual rate paid by company C is (1+2.5%) ^ 4 – 1 = 10.38%, which is slightly higher than the rate paid by company B in this case. Recall why it is called compound rate.

What to be concerned more is when the loan contract does not indicate fix rate, which means floating compounded rate, the whole budgeting analysis for more involving cashflow items would be irrelevant. Related to the main topic of IRR, one solution to this case could use different rates for negative and positive cashflows. That way, the calculation could be more accommodative to internal situations. Yet, it will still need a careful measure.

6. Why people keep using IRR if it is vague?

There are at least 3 levels in capital budgeting analysis. 1. Standalone risk of a project. This assumes the company runs the project has only one project, the one that is being observed. This is obvious enough to interpret it as the boundary discussion of thispaper. 2. Risk contribution to the firm; 3. Systematic risk contribution. The last one will involve capital assets pricing models(CAPM). IRR on those levels will still use the same basic formula, yet it will lead to more complex IRR rules such risk-adjusted return required by shareholders.

Montier from Society Générale once said: As regular readers will know, I believe that forecasting cashflow is a waste of time…. From the point of view of DCF (Discounted Cash Flow), the forecasts are central. Most DCFs are based on relevant cash flows years into the future. However, there is no evidence that analysts are capable of forecasting either short-term or long-term growth. The research provides level of error in cashflow forecast in The US and Europe stock exchange within period of 2001 - 2006. During those 5 years, error reached 20-30% and run up to 50% in the next 10 years.

So why is it IRR remains favorite for capital budgeting? As we have been through this paper, IRR approximates the rate. Thus, we do not have to bother ourselves knowing or assuming the actual capital cost opportunity to let our audience know the return prospect of a project proposal. NPV profile would anyway take more role and more reliable in this case. Subsequently, IRR is easier to understand. When we deal with investment planning, we may get overwhelmed with numbers especially those preceded with dollar sign. We may still hold for how much investment needed, but we are losing the sense when the discussion goes deeper on how much tax, how much increase, and many more “how much”s written with dollar signs.

It is much less mundane to know how much in percent than how much in dollar. The analyst team would explain further about the rate against NPV anyway.

7. What's then and how is it applied in civil engineering industry?

This paper has no intention to discourage the use of IRR for financial return analysis. Whenever a project proposal has an emergency nature, or for public development, the whole IRR discussion in this paper is no longer relevant. For commercial budgeting purposes, to avoid the overconfidence or prudence trap, the analysis should embrace the bias within and be objective by not insisting "show must go on" in discussions. One way is by eagerly questioning the curious "What can go wrong?" and "What might get better?" queries. In this paper, though it is limited to NPV against IRR and we did as much to cover those. We are doing this basically to stay away from the most pitfall as far as we could. We may not know what is going to happen, but we can determine ranges of possible outcomes through modeling.

Basically, for us to take IRR relevancy with the least considerations is to have it with high cashflow certainty. This could be a bank deposit, stocks or payment installment or anything with more than certain cashflow. Here IRR is basically the investment yield of maturity itself.

In construction industry, the use of budgeting may not be in full strained and extended compared to its use in corporate finance. The main point of budgeting in construction is usually about to assess whether or not a project to be executed. This paper intends to fine tune its application not only in a financial feasibility of a construction project, but also in businesses related to it i.e., a further development of a commercial seaport on top of its technical feasibility. After many technical forecasts on its water navigation, berth and land facilities requirements, costing analysis is an irreplaceable step that heavily discusses about cashflow and interest rate.

A development plan of a commercial seaport is approached from many disciplines. Its treatment may be regarded as corporate finance budgeting that involves tax and multiple funding schemes that would see volatile hurdle rate fluctuations affect its cash flow during operation. Whether it is for green field or brown field development, it requires a complex set of study and careful financial budgeting is one of it.

Conclusion

Nikola Tesla once said: Today's scientists have substituted mathematics for experiments, and they wander off through equation after equation, and eventually build a structure which has no relation. The moral message is: Do not believe any numerical model as a whole. It is fun to play with numbers and assumptions. In this case, common sense and business sense should take more role. If someone said that he could put in a confidence as to when and how, that the business could grow into the financial model, formulate risks as no more than numbers, make things look less daunting, then this could arguably be a fraudulent claim. For better planning, suggestions and thoughts from industry experts need to be heard and accommodated into financial modeling team. We will still need them, there are certain things in life that cannot be appreciated by non-field practicing professionals. The financial modeling will not be able to completely reduce or mitigate the risk.

The higher the IRR is not always the better one. More specifically, we may feel more confident after looking at those conforming numbers from the model. The deeper we go with the analysis the more we are forgetting that the projected sale is not guaranteed. The actual rate could change way differently depending on factors. Factors that were either not included in the analysis or simply occur differently. Those performed analysis above are to help understanding better for better decision making. Though the main discussion in this paper is about the choice of using certain interest rate in financial analysis, the conclusions in this paper are applicable in civil engineering projects.

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