Decision Making Using Engineering Economic Tools: A Real Case Study

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Abstract

Appropriate financial decisions are important for success of any company. Sometimes, erroneous selection of project or investment ruins the overall company's financial condition. There are number of financial or engineering economic tools available but the appropriateness of a given project, estimate its value, and justify it from an engineering economics standpoint is the key. It's known that engineering economics provides the tools and techniques in evaluating alternatives economically and source of many engineering decisions are based on engineering economics. In this paper, we will make economics decision for the location of copper mining plant using traditional engineering economics tools like cash flow, depreciation, and spider diagram and sensitivity analysis by using a real case study.

Introduction

Being a financial manager or shareholder, there are many questions arises in your mind that which engineering projects are worthwhile, which engineering projects should have a higher priority or which is the best alternative that is economically feasible considering the current financial condition of the company. Moreover, which project will give you more and quick rate of return. Wrong selection of alternative will cost you more than your imagination.

Economic analysis is inevitably an important tool in the decision making process [1]. It is essential for any stake holders to know the economic feasibility of project or investment before starting new projects. Moreover, if you have more than one alternative, it is recommended to perform feasibility analysis.

Planning and Control are the two most important ingredients to a Successful Business. A Business Plan takes most of the guess work out of Business Strategy and Control through solid financial analysis. Financial Data provides a way to gauge where you are in your Strategic Plan, telling you where changes in your Plan are necessary. Because of this, Financial Data Analysis and Management are vitally important to running a successful business [2].

Some of financial tools are very straight forward and easy to use and interpret like cash flow analysis, financial rations and depreciation etc. Furthermore, some tools are tedious to implement and interpret like Spider Diagram and Tornado Analysis.

The objective of this case study is that we analyze the worth of investing in a new project based on the company's current financial situation and by using certain principles of money-time relationship. It includes a consolidated balance sheet (Table 1), profit and loss statement and the company's financial plan for the next five years. The various alternatives available are also compared and finally the ones giving the best attractive returns and future growth are selected.

At last we will be able to select best alternative, which is economically feasible and suits companies financial plans and fulfill shareholders expectation for that project/investment.

Brief Description of Engineering Economics Tool

Cash Flow Diagram

Cash flow is the stream of monetary (dollar) values—costs (inputs) and benefits (outputs)-resulting from a project investment [3].

Time Value of Money

Time value of money is defined as the time-dependent value of money stemming both from changes in the purchasing power of money (inflation or deflation) and from the real earning potential of alternative investments over time [3].

Financial Ratios

A financial ratio helps you in better understanding and guides the financial affairs of your business. A ratio is a mathematical expression and is computing using information is your balance sheet and / or income statement [4].

Depreciation

Depreciation is defined as an accounting methodology which allows an organization to spread the cost of a fixed asset over the expected useful life of that asset. The cost of the fixed asset immediately comes out of the cash account of the organization and is entered as an asset for the organization. At the end of each period of the useful life of the asset a part of the cost is expensed. This amount is added to the accumulated depreciation for the asset. The net value of the asset on the books of the organization is the asset account less the accumulated depreciation account [5].

Straight-Line (SL) Method

Straight-line method is the simplest depreciation method. It is assumes that a constant amount is depreciated each year over the depreciable life of the asset.

Declining Balance (DB) Method

In the declining balance method sometimes called the constant percentage method or the Matheson formula, it is assumed that the annual cost of the depreciation is the fixed percentage of the BV at the beginning of the year. The ratio of the depreciation in any one year to

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the BV at the beginning of the year is constant throughout the life of the asset is designated by R ($0<=R<=1$). In this method, R = 2/N when a 200% declining balance is being used (i.e. twice the straight-line rate of 1/N) and N equals the depreciable (useful) life of an asset. If the 150% declining balance method is specified, then R=1.5/N. The following relationship hold true for the declining balance method: $d_t = 1-(S.V/P) 1/N$.

Sum-of-The-Year-Digits (SYD) Method

To compute the depreciation deduction by the SYD method, the digits corresponding to the number for each permissible year of life are first listed in reverse order. The sum these digits is then determined. The depreciation factor for any year is the number from the reverse-ordered listing for that year divided by the sum of the digits [6].

Declining Balance with Switch-Over to Straight-line

Because the declining balance method never reaches a BV of zero, it is permissible to switch from this method to the straight-line method so that assets SVN will be zero (or some other desired amount). Also this method is used in calculating the MACRS recovery rates.

The Internal Rate of Return

The Internal Rate of Return (IRR) is defined as the interest rate that makes the project have a zero Net Present Value (NPV). IRR is an alternative method of evaluating software investments without estimating the interest rate. IRR takes into account the time value of money by considering the cash flows over the lifetime of a project.

Spider Diagram

This approach is used when two or more project factors are of concerns and an understanding of the sensitivity of the economic measure of merit to changes in value of each factor is needed.

Break Even Chart

In its simplest form, the break-even chart is a graphical representation of costs at various levels of activity shown on the same chart as the variation of income (or sales, revenue) with the same variation in activity. The point at which neither profit nor loss is made is known as the "break-even point" and is represented on the chart below by the intersection of the two lines.

Breakeven Analysis

This technique is commonly used when the selection among project alternatives or the economic acceptability of an engineering project is heavily dependent upon a single factor such as capacity utilization, which is uncertain [7].

	31-Mar-04	31-Mar-03
FIXED ASSETS (intangible fixed assets + goodwill + Investment in associate)	1,311.20	923.2
CURRENT ASSETS (accounts receivables + debtors + cash in hand)	1,686.60	490.5
TOTAL ASSETS	2,997.80	1413.7
CURRENT LIABILITIES	881.8	498.1
LONG TERM DEBTS	986	105
STOCKHOLDERS EQUITY retained earnings)	1,130.00	810.6
TOTAL LIABILITES	2997.8	1413.7

Table 1: Consolidated Balance Sheet (US$ millions).

Sensitivity Analysis

In the economic analysis of most engineering projects, it is helpful to determine how sensitive the situation is to the several factors of concern so that proper consideration may be given to them in the decision process. Sensitivity, in general means the relative magnitude of change in the measure of merit (such as PW or IRR) caused by one or more changes in estimated study factor values. Sometimes sensitivity is more specifically defined to mean the relative magnitude of the change in one or more factors that will reverse a decision among project alternatives or a decision about the economic acceptability of a project.

Case Study

Company Background

M Industries India Ltd. was founded in 1986 bringing together several metal related activities. Its revenues today are worth $2 billion and the company has several mines and refineries of aluminum and zinc in India. M industries not only enjoy a very high market share of its end products in India (48% of aluminum products and 75% of zinc products) but also export its products to more than 35 countries. The listing of M Industries on the London Stock Exchange last year was yet another feather in its hat and the company was able to generate US$825 million, net of cash through its IPOs.

Aluminum Activities

- Operating Companies:
- Bicks Aluminum Company (BALCO)
- Micks Aluminum Company (MALCO)
- Turnover: US$224.4 million
- No. of Employees: 5,531
- Annual Capacity: 135,000 tpa (tonnes per annum)
- Zinc Activities
- Operating Company: AAS Zinc Ltd. (AZL)
- Turnover: US$ 550.7 million
- No. Of Employees: 5,942
- Annual Capacity: 176,000 tpa (tones per annum)

Executive Summary

The company has decided to venture into copper mining and refining based on the high demand of this metal in the world market. The estimated global demand grew at around 2.6%, nearly twice the level of supply. This was largely due to the increased demand from China for refined metal and some unplanned shutdowns at substantial mines, all leading to a very tight global market. Stocks of copper reduced significantly over the year and copper prices reached a nine-year high of 136 US cents per pound (Table 1).

The above balance sheet provides a snapshot of the firm's financial position at the end of years 2003 and 2004 and we can also see that there has been a substantial improvement in the assets and liabilities of the company. It actually shows that the company has strengthened its business over the previous year (Table 2).

From the income statement shown above, we can make the followings inferences:

		Fiscal Year Ended	
		31-Mar-04	31-Mar-03
		US$ (millions)	US$ (millions)
Group turnover		1,289.50	963.1
Gross profit		315.6	229.4
Group operating profit		237.1	114.6
Profit on ordinary activities before interest and taxation		234.7	113.4
Profit on ordinary activities after taxation		157.4	57.9
Profit for the financial year		66.6	24.5
Retained profit for the financial year		50.8	24.5
Basic earnings per share (US cents/share)		23.3	8.6

Table 2: Consolidated Profit And Loss Statement.

	Year ended 31-Mar-04 US$ million	Year ended 31-Mar-03 US$ million
Net cash inflow from operating activities	496.3	233.5
Returns on investments	-16.7	-33
Taxation	-57.5	-25.5
Capital expenditure and financial investment	-353.6	-43.3
Acquisitions	-81.1	-188.9
Cash outflow before use of liquid resources and financing	-12.6	-57.2
Management of liquid resources	-1,065.00	9.8
Financing	1,061.60	94.6
(Decrease)/increase in cash in the year	-16	47.2
Increase/(decrease) in net cash/(debt) resulting from cash flows	786.5	-61.3
Increase/(decrease) in net cash/(debt) for the year for the year	753.4	-100.2
Net cash/(debt) at the end of the year	422.3	-331.1

Table 3: Consolidated Cash Flow Statement.

Cost of Thalanga Mine	150
Cost of Mt. Lyall Mine	200
Cost of Refinery at Tuticorin	100

Table 4: Investment Requirement.

S.No.		CRL Australia	ASARCO (USA)
		($ millions)	($millions)
1	Smelter	30	33
2	Refinery	13	11
3	APM (Anode Preparation M/C)	12	10
4	CSM (Cathode Stripping M/C)	15	13
5	ASWM (Anode Scrap Washing M/C)	8	8
6	CCR (Continuous Copper Rod) Plant	10	9
7	STP (Slime treatment Plant)	7	6
8	ETP (Effluent Treatment Plant)	2	2
9	Installation and Transportation	1	2
	Total	98	94

Table 5: Quotations for Machinery for CRL & ASARCO.

- The company has made profits in both of its financial years i.e. 2003 and 2004.
- The profit in the year 2004 is much higher (almost 250%) than in 2003, which clearly indicates that the company has been performing at an excellent level.
- The shares of the company have also performed well on the stock market.

The cash flow statement shows that there was a greater amount of outflow of cash during the year 2003 whereas at the end of year 2004 the company has surplus cash. This is basically due to the fact that large amount of capital was generated from the company's IPO and it is the correct time when the company should consider investing this money in a big project. Hence the decision of company's venture in the copper production is justifiable (Table 3).

Capital Required

The ores of copper are available in Australia, Africa and in parts of North and South America. The company wishes to have its manufacturing facility in India because of following reasons:

- Cheaper Labor costs.
- Easier access to the markets of Asian countries like China, Malaysia, Indonesia, Taiwan and Japan and of course India.

Hence the company decides to acquire 2 copper mines in Australia at Thalanga and Mt. Lyall. In order to minimize the transportation cost and time, it is decided that the company to set up the refinery at Tuticorin, a port in the southern part of India, which would be nearest to Australia.

The estimated investment would be approximately US$ 450 million. The breakup of this cost is shown below (Table 4):

Total = US$ 450 million

Copper Refinery Limited, Australia (CRL) and American Smelting and Refining Company, USA (ASARCO) are the two companies which take up projects for setting up the copper refineries throughout the world. Their quotations for various machines, installation, freight etc. are shown below (Table 5):

Since the company has a surplus of US$ 422 million, it still requires approx. US$ 28 million to meet the requirement.

'M Industries' does an analysis of the costs involved in both the projects using the IRR method. The company sets its MARR as 25%.

- The life of machines procured from CRL is stated to be 12 years where as that of ASARCO is 10 years.
- The annual maintenance cost for machines and equipment's used in STP, ETP etc. for CRL is approx. $2 million whereas for ASARCO is approx. $1.5 million.
- The salvage value at the end of the life time for CRL is $ 6 million and for ASARCO is $5 million.

(Figures 1 and 2) below shows the cash flows

of both option, CRL Australia and ASARCO, USA Based on cash flows, Present worth (PW) and internal rate of return will be calculated for both projects (Figures 1 and 2) .

$$PW = -94 + 30 (P/A, I^*, 10) - 1.5 (P/A, I^*, 10) + 5(P/F, I^*, 10) = 0$$

$$I^* = 27.85 \%$$

The internal rate of return of both projects is greater than the MARR. Hence we now compare them using the future worth (FW) method considering a study period of 12 years.

CRL: FW 12 (25%) = - 98 (F/P,25,12) + 30 (F/A,25, 12) – 2(F/A, 25, 12) + 6
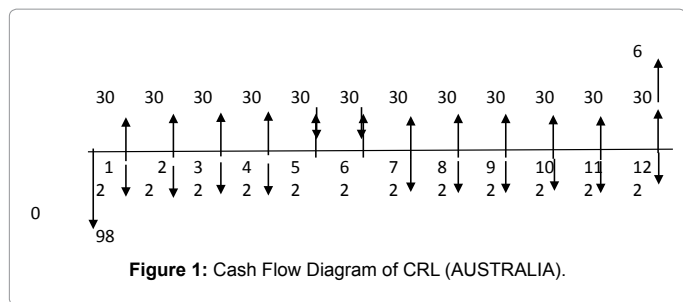
= $98.13 million.
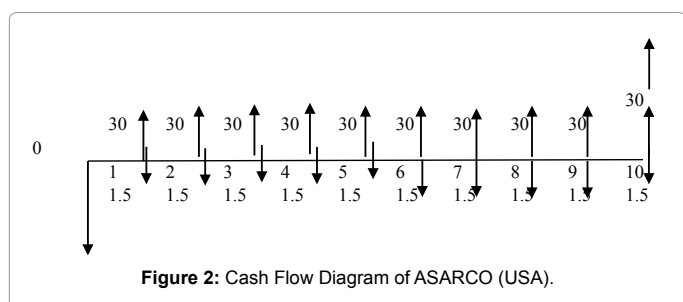
Figure 1: Cash Flow Diagram of CRL (AUSTRALIA).

Figure 2: Cash Flow Diagram of ASARCO (USA).

Bank	Interest Rate	Effective Interest Rate
CITIBANK	12% compounded semi annually	12.36% p.a.
HSBC	11.75% compounded quarterly	12.27% p.a.
UOB	11.70% compounded monthly	12.35% p.a.

Table 6: Different Banks Interest Rate.

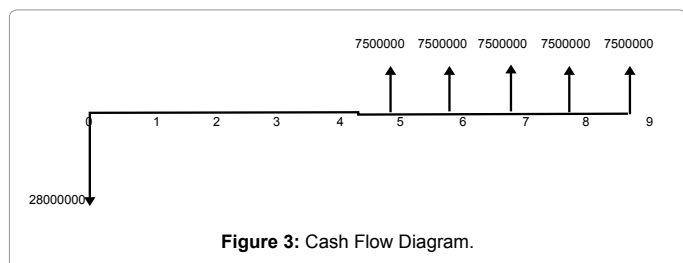| Quarters	Cash Flow	Interest per qr.	Cumulative Cash
0	-28000000		-28000000
1	0	-822500	-28800500
2	0	-846660	-29669160
3	0	-871530	-30540690
4	0	-897130	-31437820
5	7500000	-923490	-24861310
6	7500000	-730300	-18091610
7	7500000	-531440	-11123050
8	7500000	-326740	-3949790
9	7500000	-116025	3434180

Table 7: Discounted Pay Back Period.

Figure 3: Cash Flow Diagram.

ASARCO: FW 10 (25%) = - 94 (F/P, 25, 10) + 30 (F/A, 25, 10) – 1.5 (F/A, 25, 10) + 5 = $ 77.27 million

FW 12 (25%) = 77.27 (F/P, 25, 2) = $ 120.73 million

Since the future worth of the second project is greater than that of the first one, the company decides to purchase its machinery and workstations from ASARCO.

It is decided that the company would generate the remaining amount by availing loan from a bank. The company considers reviews the interest rates of the following banks and finally decides to avail the loan from HSBC as its effective interest rate per annum is the least (Table 6). The refinery to be set up at Tuticorin would have a capacity of producing 120,000 tpa of copper.

Financial Plan

The company would avail loan from Jan. 1st, 2006 onwards and until then would utilize the money generated from its IPOs for the purchase of mines in Australia and setting up the smelting and refinery plants at Tuticorin. It is now interested in estimating the capital recovery. The following data is used to calculate the breakeven point.

- The smelters and refinery would be set up by August 2006 and the company can start its production from September 2006 onwards. The company also decides to have quarterly cash flows (K=4). Hence the first amount will be on Jan. 1st, 2007.

- Capacity = 120,000 tons per annum

- The estimated profit per tons (after deducting the raw material, transportation, machining and overhead costs from the selling price) = $ 250.

Hence, the estimated profit per quarter = (120000/4) * 250= $ 7,500,000

We determine the break-even point by using the discounted payback period (Table 7) as follows. Since the compounding period (M) is equal to the number of cash flows (K) (Figure 3), the effective interest rate per quarter is

I* = r / M   = 0.1175 / 4 = 2.9375% (Table 7).

From the above table we see that the payback period is the 9th quarter. Hence the company would be able to clear all its debt approximately by the end of the second year. The depreciation of the machines is shown in the below using the Sum of the Year Digits Method. The estimated book value of the all the machines at the end of 10 years is $5 million. The following table uses the SOYD method to calculate the depreciation amounts per year for ASARCO over a period of 10 years at the end of which the salvage value is $ 5 million (Table 8, Figure 4).

In order to determine the influence of each factor on the final result, sensitivity analysis will help decision maker to identify which factors are more critical in the economic decisions (Table 9). As we know that there are enough degree of uncertainty is there in predicting future, it is essential to know how much our economic analysis depends on the magnitude of the estimates. In order to overcome such uncertainty, sensitivity analyses of both projects are mentioned in below (Figure 5 and 6).

EOY	SOYD Dep. Factor	dk	BVk
0			94
1	18.18%	16.18	77.82
2	16.36%	14.56	63.26
3	14.55%	12.95	50.31
4	12.73%	11.33	38.98
5	10.91%	9.71	29.27
6	9.09%	8.09	21.18
7	7.27%	6.47	14.71
8	5.45%	4.85	9.86
9	3.64%	3.22	6.64
10	1.82%	1.62	5

Table 8: Depreciation.

Years	PW (CRL)	P PW (ASARCO)
1	($70.80)	($67.20)
2	($53.84)	($49.76)
3	($40.27)	($35.81)
4	($29.42)	($24.65)
5	($20.73)	($15.72)
6	($13.79)	($8.57)
7	($8.23)	($2.86)
8	($3.78)	$1.71
9	($0.23)	$5.37
10	$2.62	$8.30
11	$4.89	$10.64
12	$6.72	$12.51
13	$8.17	$14.01
14	$9.34	$15.21
15	$10.27	$16.16

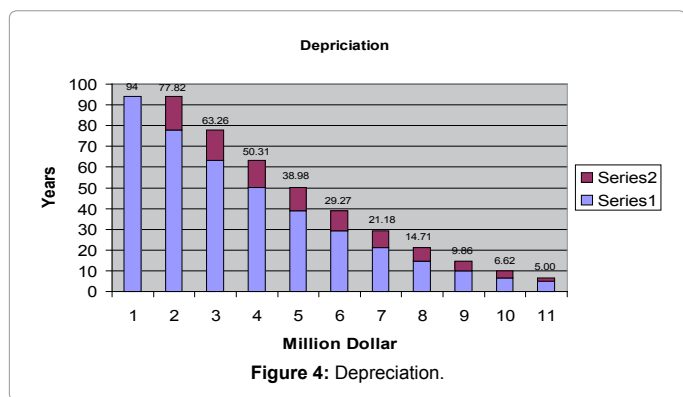**Table 9:** Sensitivity Analysis of CRL and ASARCO.
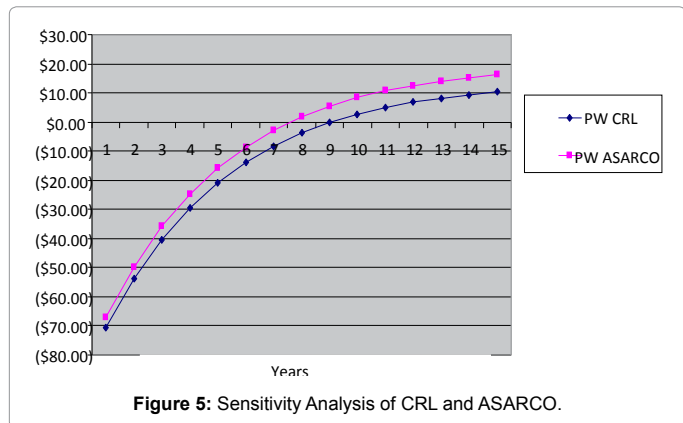

Figure 4: Depreciation.

Figure 5: Sensitivity Analysis of CRL and ASARCO.

Hence we see that the project is most sensitive (Table 10 and 11) to the annual revenues and expenses and is least sensitive to the market value (Figure 7).

Decision Reversal

The following table compares the decision reversal for ASARCO and CRL for their initial investment, salvage value and estimated life. It is also inferred from the table, if the initial investment of CRL is brought down from $98 million to $92.32, then this project becomes more preferable (Table 12).

The cash flows after the payment of tax (income tax rate = 36%) for ASARCO are given below (Table 13).

Hence we see that the project is still profitable even after the payment of taxes @ 36%.

Conclusion

The above study shows that every financial tool has its importance but in a real working environment we should utilize the benefits of all of them in order to get the best solution. Moreover, the decision reversal
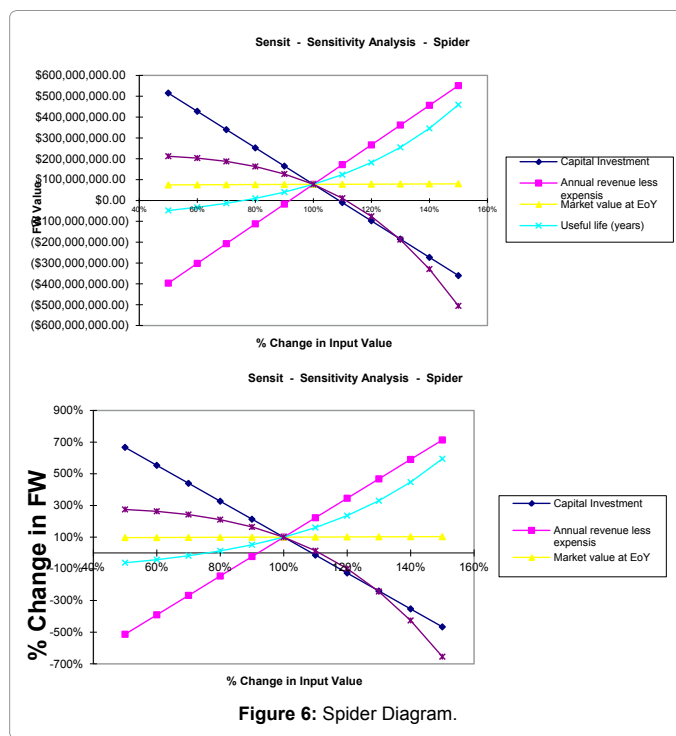

Figure 6: Spider Diagram.

	Cash flows
Capital Investment	($94,000,000.00)
Annual revenue less expensis	$28,500,000.00
Market value at EoY	$5,000,000.00
Useful life (years)	10
MARR	25%
FW	$77,264,514.92

Table 10: Tornado Table.

	LOW	BASE	HIGH
Capital Investment	(80,000,000.00)	($94,000,000.00)	(120,000,000.00)
Annual revenue less expensis	22,000,000.00	$28,500,000.00	40,000,000.00
Market value at EoY	2,500,000.00	$5,000,000.00	8000000
Useful life (years)	7.00	10	15
MARR	20%	25%	30%

Table 11: Tornado Table.
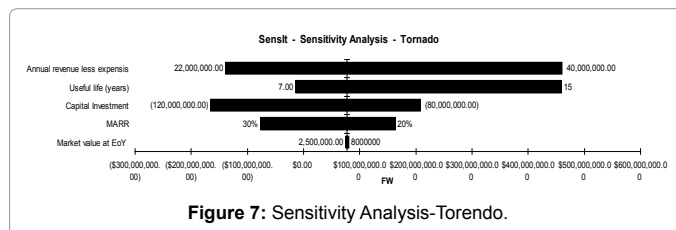
Figure 7: Sensitivity Analysis-Torendo.

	Most Likely Estimate	Estimate to Make	Change in Estimate	% Change
		CRL Preferable	Value	
Initial Investment	98	92.32	5.68	-5.8%
Salvage Value	6	6.256	0.256	4.27%
Estimated Life	10	13.15	3.15	31.50%

Table 12: Decision Reversal.

Year	BTCF	Depreciation	Taxable Income	Income Tax	ATCF
0	-94				-94
1	28.5	16.18	12.32	4.4352	24.0648
2	28.5	14.56	13.94	5.04628	23.45372
3	28.5	12.95	15.55	5.6291	22.8709
4	28.5	11.33	17.17	6.21554	22.28446
5	28.5	9.71	18.79	6.80198	21.69802
6	28.5	8.09	20.41	7.3476	21.1524
7	28.5	6.47	22.03	7.9308	20.5692
8	28.5	4.85	23.65	8.514	19.986
9	28.5	3.22	25.28	9.1008	19.3992
10	28.5	1.62	26.88	9.6768	18.8232
10	5		5	1.8	3.2

Table 13: After Tax Cash Flow.

indicates that Spider and Tornado analysis is the key in selecting the best alternative and in some cases they will reverse the result (as they did in above case study). The outcome or results of the above case study are as follows.

- ASARCO is a 10 year life project whose initial project cost is $94 million. Since company is short of $28 million to overcome this shortage of investment, it must take loan from HSBC which is giving loan at lowest interest of 12.27% per year for which company has to return $5.01 million annually.

- We have selected Double Declining Balance model for our depreciation because it is according to company policy, since it will give maximum depreciation

- In order to meet the breakeven point the company must produce 92042 tons of copper and the break even cost is $275.39 million.

- The project will start giving positive returns on investment after 7.81 years at 25% MARR which is the discounted payback period of the project.

- The internal rate of return of the project is 27.85% which is higher than the MARR which is 25 %.

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