Volume 3, Issue 1, January 2013 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

# Economic Worth Estimation of A Software Reuse Based Program

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***Abstract— To be successful a software reuse program should be economically worth able. Up-front investment is required for long- term, without any payoff realization and guarantee of benefits for projects that are developed by reusing artefacts and investment profile for such type of projects are different from those that are made from scratch. Before implementing a reuse program, cost of all factors, expected benefits, supporting metrics and legal issues should be identified as well as analyzed. The proposed research presents investment analysis techniques to estimate economic worth of the software reuse based program by using simplified and enhanced methods that extends pioneering contributions of other researchers in this area.***

***Keywords— Capital budgeting techniques, Economic functions, Software reuse investment***

## I. Introduction

"Investment is the act of putting money, effort, time, etc. into something to make a profit or get an advantage, or the money, effort, time, etc. used to do this"[4]. An organization invest some set-up capital in the hope of recovering this investment as well as a substantial proportion of the benefits within some predefined time period and "Difficult economic and market conditions are forcing software development teams to do even more with less, and to become even more responsive to customer needs"[3] .So, expected benefits , break even time and first significant reuse should be analyzed before a reuse investment[2].

### A. *Prerequisite for Investment*

1) *Investment characterization factors*

To determine economic worthiness of an investment, an organization must consider following factors[5][8][9][10] [15].

- ✓ Investment Costs
- ✓ Investment period generally 3 to 5 years
- ✓ Discount value(Rate of Interest) generally 10% to 20%
- ✓ Provisions for risks

### B. *Investment analysis functions*

Various capital budgeting techniques (functions) have been suggested[6][10] [15][12][8][9] to quantify investment decision factors but mainly following of them are used to estimate the economic worth of a reuse program as shown in Fig.1

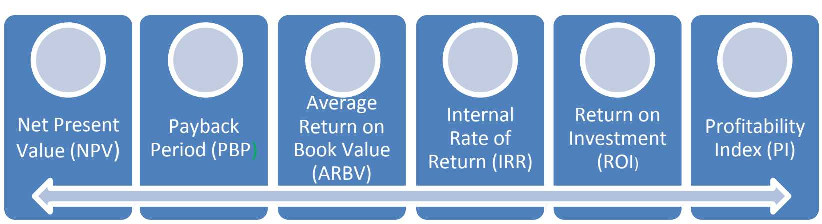



*Fig 1. capital budgeting techniques*

- Net Present Value (NPV)

It is considered best, easiest and useful method for profitability evaluation and analyzation of a capital investment for a project [10] and is the expected economic contribution of a project that is additive and allows evaluation of combinations of projects while taking into account differences of scale [15].

- Payback Period (PBP)/Breakeven point

It is the number of years required to recover the initial cash investment and measures how quickly investment money may be recouped. It is also a better measure than ARBV because it considers cash flows rather than accounting profits [6].

- Average Return on Book Value (ARBV) /Return on assets (ROA) / Average rate of return (ARR)

It is a simple measure that is based on accounting information data (profits after taxes) [6]. "It is an arbitrary rule without economic basis and can lead to incorrect capital investment decisions" [9].

- Internal Rate of Return (IRR)

"The maximum rate of return that can be paid for the capital employed over the life of the investment without loss on the project" [8] or it is the discount rate that makes NPV equal to zero[6] and is more difficult to calculate than NPV and PI .

- Return on Investment (ROI)

It is useful measurement tool that is used to evaluate and compare the efficiency of an investments[12] and to measure the impact of projects that support company strategies to improve productivity, infrastructure, competitive positioning, or reduce environmental impact as well as [11] to validate a proposal's potential cost savings. .

- Profitability Index (PI).

It is benefit-cost ratio that is used to estimate the expenses and earnings of an organization that is neither additive and not sensitive to scale. PI is not as reliable as NPV since a higher PI will not necessarily increase the value of one investment over another[5].

## II. Related Work

There are many factors which has impact on cost of reusable software. Various models are proposed by researchers for each factor. But, no standard has proved to be complete to solve the all problems related reuse cost. Literature has a plethora of software reuse cost models that have contributed in cost-benefit analysis in which a very few estimated economic worth of a reuse program. [1][ 19] have calculated only ROI, [17 ] have calculated ROI and NPV and [20,22,24,18 ] have calculated ROI and PBP (break even point) , those are not sufficient to take decision about investment. Study[5] has calculated almost all investment analysis functions that is complex .In this research, some necessary and sufficient economic functions are calculated for the reuse oriented organization to estimate economic worth of its software reuse based program well as some measurement tools-metrics and models are reviewed for this by simplifying, extending and filling the gap left by other studies.

## III. Proposed Work

### A. *Estimation of economic worth for proposed reuse scheme*

**Table1: Components Details**

| Year | Component | Size |
|---|---|---|
| 2007 | X1 | 5k |
| 2008 | X2 | 10k |
| 2009 | X3 | 15k |
| 2010 | X4 | 20k |

We are estimating worthiness of a reuse program in a hypothetical scenario of a corporation that starts its reuse initiative with domain engineering in 2007 developing reusable components as shown in Table1, that are used in applications internally as shown in Table2, and are also sold externally to corporation for a period of 4 years and discount rate is12%. The following assumptions are made with respect to this program :

- ✓ Cost of the reused components is double as compared to similar components made for single use.
- ✓ Salary of employees is fixed, not depending upon size and quantity of components .Overhead cost to make reusable components is 10 % of salary of employees and all other details are as shown in Table3.
- ✓ Cost of purchased component(yi ) that are used in applications is 25% extra of cost of internally developed component(yi).
- ✓ Sell price of internally developed components and applications is 25% extra of their respective costs.
- ✓ Set-up cost of corporation for reuse program is $3,000 and of application- engineering cycle is $1,000 .
- ✓

**Table 2: Applications Details**

| Year | Application | Component used internally developed | Component used externally developed | Additional-Code |
|---|---|---|---|---|
| 2008 | App(1) | X1 | $O_1$ | 2K |
| 2009 | App(2) | X1,X2 | $O_1, O_2$ | 4K |

| | | | | |
|---|---|---|---|---|
| 2010 | App(3) | X1, X2,X3 | $O_1,O_2,O_3$ | 6K |

**Table 3: Salary of Employees**

| Personnel | Initial Salary ($) | Increment/y (%) |
|---|---|---|
| Component developer for reuse | 1000 | 15 |
| Manager for reuse | 800 | 10 |
| Librarian for reuse | 700 | 10 |
| Domain Analyst | 800 | 10 |

To avoid complexity and sake of near about completeness, NPV,PBP,ROI functions are included, calculated and explained to estimate the economic worth of the proposed model.

*1) Net Present Value (NPV)*

NPV compares the value of a currency today to the value of that same currency in the future, taking inflation and returns into account. NPV represents a hypothetical value not a certified value that considers scale, time value of money, risk and magnitudes of the projected cash flows of the project [5]. ]. NPV is discounted ROI.

An investment is beneficial if the NPV > or =0 .So, all independent projects with a positive NPV should be accepted. When choosing among mutually exclusive projects, the project with the largest (positive) NPV should be selected [14 ]. NPV may be calculated using any suitable following methods.

- Method1

It is sum of difference between the present value of project's cash inflows and the present value of project's cash out flows. i , e

$$NPV = \sum_{t=0}^{T} \frac{CF_t}{(1+r)^t} = CF_0 + \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \dots + \frac{CF_T}{(1+r)^T}$$

, where $CF_t$ is the cash flow at time t and r is the cost of capital [7 ].

- Method2

$$NPV = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - C_0$$

[14]

- Method3

$NPV = [\sum \{B(ID+y) - C(ID+y)\}/(1+R)^y] - IC$ , $1<=y<=Y$

Or $NPV = \sum [(B(ID+y) - C(ID+y)/(1+R)^y]$ , $0<=y<=Y$ [5]

- Method 4

This method is used in excel .Net present value of an investment by using a discount rate and a series of future payments (negative values) and income (positive values).

NPV (rate, value1, value2, ...)

Where

Rate - discount rate over the length of one period.

Value1, value2 , ... - arguments representing the payments and income that must be ordered, equally spaced in time and occur at the end of each period [16].

In proposed work, NPV for each year of corporation as shown in Fig.2 is calculated by reviewing above method 1 and summarized in Table.4 and Graph.1

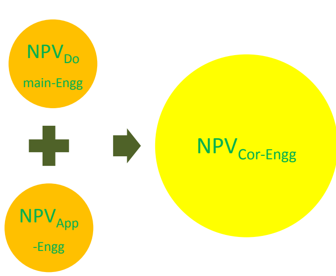



*Fig . 2 NPV of corporation*

$NPV_{Cor-Engg} = NPV_{Domain-Engg} + NPV_{App-Engg}$

$NPV_{Domain-Engg} = NPV_{comp-Engg} - Salary_{Dom-Analyst}$

- Component-Engg. Cycle NPV

NPV is calculated at the end of each year and fees and royalties are considered at the end of 4 year program, i,e Other than fees and royalties all revenues are considered as discounted values.

$$NPV_{comp\text{-}Engg} = \sum_{t=0}^{3} \left(\frac{(cash\ inflows\ - cash\ outflows\ )}{(1+discount\ \ rate\ )^t}\right) + \text{fees and royalties+ component X4} \qquad [21][23]$$

$$\sum_{t=0=y2007}^{3=y2010} \left(\frac{(Total\ sell\ price\ - Total\ investment\ )}{(1+discount\ \ rate\ )^t}\right) + \text{ fees and royalties+ component X4}$$

$NPV_{comp\text{-}Engg}$= (Total sell price – Total investment)$_{2007}$ /$(1.12)^0$+( Total sell price – Total investment)$_{2008}$ /$(1.12)^1$ +( Total sell price – Total investment)$_{2009}$ / $(1.12)^2$ +( Total sell price – Total investment)$_{2010}$ /$(1.12)^3$ +fees and royalties +component X4

$$NPV_{comp\text{-}Engg} = \left(\frac{(-2750)}{(1.12)^0}\right) + \left(\frac{(3850\ )}{(1.12)^1}\right) + \left(\frac{(4314.063)}{(1.12)^2}\right) + \left(\frac{(4836.391)}{(1.12)^3}\right) + \text{ fees and royalties +component X4}$$

$NPV_{comp\text{-}Engg}$= = -2750 +3437.5+3439.144+3442.447+[(116.0156+3869.113=3985.128)]
= 11554.22

- Domain Engg. Cycle NPV

$NPV_{Domain\text{-}Engg}$ = $NPV_{comp\text{-}Engg}$- $Salary_{Dom\text{-}Analyst}$

$NPV_{Domain\text{-}Engg}$ = [$NPV_{comp\text{-}Engg(2007)}$-($Salary_{Dom\text{-}Analyst\ 2007}$)/$(1.12)^0$] +[ $NPV_{comp\text{-}Engg(2008)}$-($Salary_{Dom\text{-}Analyst\ 2008}$)/$(1.12)^1$] + [ $NPV_{comp\text{-}Engg(2009)}$ -($Salary_{Dom\text{-}Analyst\ 2009}$)/$(1.12)^2$] + [ $NPV_{comp\text{-}Engg(2010)}$-$Salary_{Dom\text{-}Analyst\ 2010}$)/$(1.12)^3$]
= (-2750-800) +(3437.5-880/1.12)+( 3439.144 − 968/$(1.12)^2$)$_+$ [7427.575 − 1064.8)/$(1.12)^3$]
= $(-3550)_{2007}$ + $(3437.5\text{-}785.7143)_{2008}$ + $(3439.144\ \text{-}771.6837\ )_{2009}$ + $(7427.575\ -757.9036)_{2010}$ =$(-3550)_{2007}$ + $(2651.786)_{2008}$ + $(2667.461)_{2009}$ + $(6669.672)_{2010}$
= 8438.918

- Application _ Engg. Cycle NPV

$NPV_{App\ -Engg}$ = [(Total sell price - (Total cost with reuse -Total cost of repeated components) ]$_{2008}$ /$(1.12)^0$+[(Total sell price -(Total cost with reuse -Total cost of repeated components) ]$_{2009}$ /$(1.12)^1$ +[(Total sell price - (Total cost with reuse -Total cost of repeated components) ]$_{2010}$ / $(1.12)^2$
=[8703.125-{(6962.5+1000)-0}]+[18469.38- {14775.5-(2750+3850)}]/1.12+[29433.98- {23547.19-(2*(2750 + 3850) − (3080 + 4314.063))}]/$(1.12)^2$
= [740.625]+[3693.875+6600])]/1.12++[5886.797+13200+7394.063]/$(1.12)^2$]
=$(740.625)_{2008}$ +$(9190.96)_{2009}$ +$(16417.46)_{2010}$
=26349.05

- Corporate_ Engg. Cycle NPV

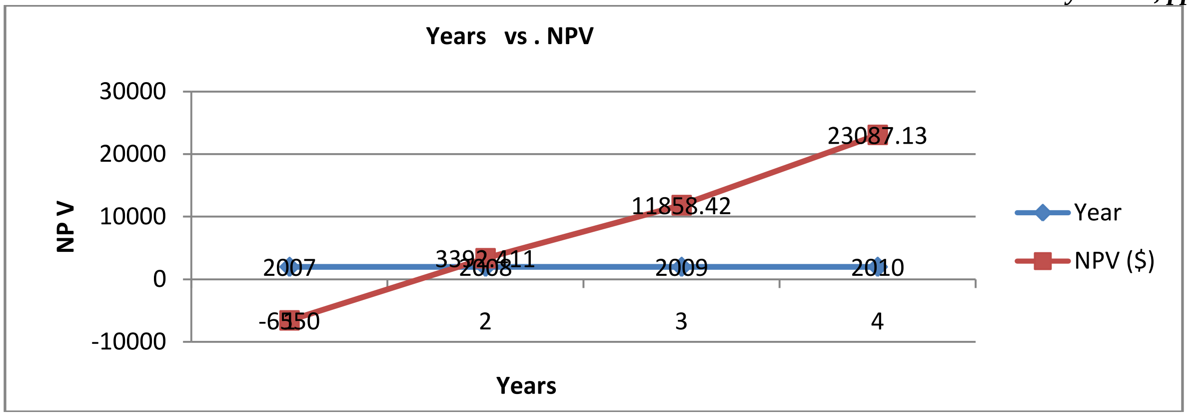
$NPV_{Cor\text{-}Engg}$= $NPV_{Domain\text{-}Engg}$+$NPV_{App\ -Engg}$

$NPV_{Cor\text{-}Engg}$= $(-3550\text{-}3000)_{2007}$ + $(2651.786+740.625\ )_{2008}$ + $(2667.461\ +9190.96)_{2009}$ + $(6669.672+16417.46)_{2010}$
=$(-6550)_{2007}$ +$(3392.411/)_{2008}$ +$(11858.42)_{2009}$ +$(23087.13)_{2010}$
=38337.96-6550
= 31787.96

Table 4: NPV(in $)

| Year | Component _ Engg. Cycle | Domain_ Engg. Cycle | Application _ Engg. Cycle | Corporate_ Engg. Cycle |
|---|---|---|---|---|
| 2007 | -2750 | -3550 | | -6550 |
| 2008 | 3437.5 | 2651.786 | 740.625 | 3392.411 |
| 2009 | 3439.144 | 2667.461 | 9190.96 | 11858.42 |
| 2010 | 7427.575 | 6669.672 | 16417.46 | 23087.13 |




**Graph.1**

2) Return on Investment (ROI)

The Return on Investment is a calculation that is commonly used by organisations to help them to decide whether they should make a particular investment or not. One of the most common reasons to calculate return on investment is to validate a proposal's potential cost savings[11]. ROI may be calculated using any suitable following methods.

- Method1

((Return – Investment)/ Investment )* 100

All of the marketing investments should be measured and tracked for ROI to improve return over time[11].

- Method 2

$$ROI = \frac{(\text{Gain from Investment} - \text{Cost of Investment})}{\text{Cost of Investment}}$$

definition, can be modified to suit the situation -it all depends on what you include as returns and costs[12].

- Method3

For short-term investment and benefits ROI may be calculated as following formula but not justifiable.

$$ROI = \frac{Financial\ Gain}{Total\ Investment}$$

For long-term investment and benefits ROI may be calculated as following formula that is more accurate.

$$\text{ROI} = \frac{\text{NPV of Benefits}}{\text{PV of Costs}} \qquad [11]$$

Dupont formula.

$$ROI = \frac{\text{Net Profit}}{Investment} \qquad [6,13]$$

In proposed work, ROI of corporation for each year as shown in Fig.2 is calculated by reviewing above method 3, ROI = NPV (Benefits)/PV (Costs) * 100% and summarized in Table.5 and Graph.2

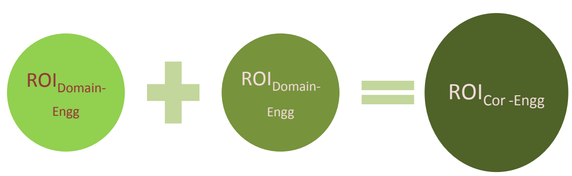



**Fig.3**

$$ROI_{Cor\text{-}Engg} = ROI_{Domain\text{-}Engg} + ROI_{Domain\text{-}Engg}$$

- Component-Engg. Cycle ROI

$$ROI_{comp\text{-}Engg} = \sum_{t=0=y2007}^{3=y2010} ROIcomp\_Engg\ (t)$$

$= [ (-2750/2750)*100]_{2007} + [(3437.5/3080)*100]_{2008}+[(3439.144/3451.25)*100]_{2009}+ [(7427.575/3869.113)*100]_{2010}$

$= [-100]_{2007} +[111.6071]_{2008}+ [ 99.64923]_{2009}+[191.971]_{2010}$

=87.86237

Or

$ROI_{comp\text{-}Engg} = NPV_{Comp\text{-}Engg}/Cost_{comp\text{-}Engg}$

=[11554.22/13150.36 ]*100

$ROI_{Comp\text{-}Engg}$= 87.86237

- Domain Engg. Cycle ROI

$ROI_{Domain\text{-}Engg} = \sum_{t=0=y2007}^{4=y2010} ROIDomain\_Engg\ (t)$

$ROI_{Domain\text{-}Engg} = [(-3550/800)*100]_{2007}+[(2651.786/880*100]_{2008} + [(2667.461/968)*100]_{2009} + [(6669.672/1064.8)*100)]_{2010}$

$= [-443.75]_{2007} + [301.3393]_{2008} + [275.5641]_{2009} + [626.3779]_{2010}$

$ROI_{Domain\text{-}Engg} = 8438.918/3712.8 = 227.2926$

- Application _ Engg. Cycle ROI

$ROI_{App\text{-}Engg} = \sum_{t=0=y2008}^{3=y2010} ROIApp\_Engg\ (t)$

$= [\{740.625/(6962.5+1000)\}*100]_{2008}\ )]+[(9190.96/14775.5)*100]_{2009} + [(16417.46/23547.19)*100]_{2010}$

$= [9.301413]_{2008} + [62.20405]_{2009} + [69.72153]_{2010}$

$ROI_{App\text{-}Engg} = (26349.05/46285.19)*100$

$= 56.92759776$

- Corporate_ Engg. Cycle ROI

$ROI_{Cor\text{-}Engg} = ROI_{Domain\text{-}Engg} + ROI_{App\text{-}Engg}$

$ROI_{Cor\text{-}Engg} = \sum_{t=0=y2007}^{4=y2010} ROIDomain\_Engg\ (t) + \sum_{t=0=y2008}^{3=y2010} ROIApp\_Engg\ (t)$

$= [(-6550/3000)*100]_{2007} + [\{(301.3393+9.301413)/200\}*100]_{2008} + [\{(275.5641+62.20405)/200\}*100]_{2009} + (626.3779+69.72153)/200\}*100)]_{2010}$

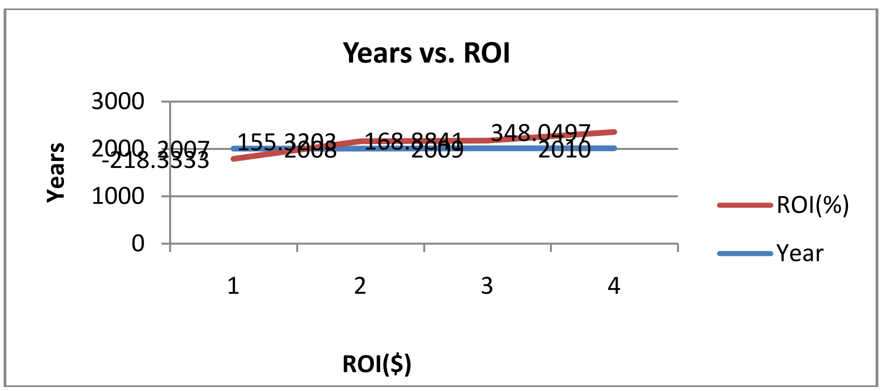
$= (-218.3333)_{2007} + (155.3203)_{2008} + (168.8841)_{2009} + (348.0497)_{2010}$

$= (453.9208103/400)*100$

$= 113.4802026$

Table.5: ROI( in%)

| For Year | Component _ Engg. Cycle | Domain_ Engg. Cycle | Application _ Engg. Cycle | Corporate_ Engg. Cycle |
|---|---|---|---|---|
| 2007 | -100 | -443.75 | | -218.3333 |
| 2008 | 111.6071 | 301.3393 | 9.301413 | 155.3203 |
| 2009 | 99.64923 | 275.5641 | 62.20405 | 168.8841 |
| 2010 | 191.971 | 626.3779 | 69.72153 | 348.0497 |




**Graph.2**

3). Payback Period

It is a arbitrary measure of the risk , liquidity of a project that considers cash flows ,some time value of money , insensitive to scale, ignore depreciation. “When the payback method is used, it is more appropriately treated as a constraint to be satisfied than as a profitability measure to be maximized” [15] since it does not measure profitability and an investment is recommended if this value is smaller than the proposed investment cycle period.

*All other things being equal, the shorter the payback period, the less risky and better investment.*

PBP may be calculated in various ways

- Method 1

Ratio of the initial fixed investment/ annual cash inflows for a recovery period [15]

- Method 2

Point where the total revenue equals the total cost [20].

- Method 3

PBP = Cost of Project/ Annual Cash Inflows [12]

- Method 3
  Payback Period = Amount to be Invested/Estimated Annual Net Cash Flow [25].

In proposed scheme, PBP of corporation for each year is calculated by reviewing above method 3 as shown in **Fig.4** , Table.6 and Graph.3

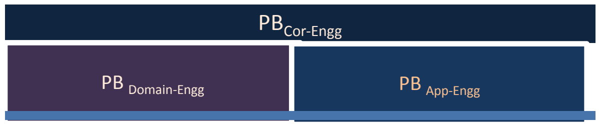



**Fig.4**

$PBP_{comp\text{-}Engg}$ year wise

$PBP_{comp\text{-}Engg} = [2750/(-2750)]_{2007} + [3080/3850]_{2008} + [3451.25/4314.063]_{2009} + [3869.113/4836.391]_{2010}$

$PBP_{comp\text{-}Engg} = [-1]_{2007} + [0.8]_{2008} + [0.8]_{2009} + [0.8]_{2010}$

Overall $PBP_{comp\text{-}Engg}$ = 13150.36/ 10250.45 = 1.282905 years

Year wise $PBP_{Domain\text{-}Engg} = [(2750+800)/(-2750-800)]_{2007} + [(3080+880)/(3850-880)]_{2008}$
$+ [(4314.063+968)/(4314.063-968)]_{2009} + [\frac{4836.391+1064.8}{4836.391-1064.8}]_{2010}$

$= [-1]_{2007} + [3960/2200]_{2008} + [4419.25/2483.25]_{2009} + [4933.913/2804.313]_{2010}$

$= [-1]_{2007} + [1.8]_{2008} + [1.779623]_{2009} + [1.759402]_{2010}$

Overall $PBP_{Domain\text{-}Engg}$ = [13150.36+(800+880+968+1064.8)]/ [ 13150.36 -(800+880+968 +1064.8)]
= 16863.16/9437.563
= 1.786813

Year wise $PBP_{App\text{-}Engg} = [(6962.5+1000)/740.625]_{2008} + [\{14775.5-(2750+3850)\}/10293.88]_{200} + [23547.19-\{(2*(2750+3850)+(3080+4314.063)\}]/20594.06]_{2010}$

$= [7962.5/740.625]_{2008} + [(14775.5-6600)/10293.88]_{2009} + [23547.19-(13200+7394.063)/20594.06]_{2010}$

$= [7962.5/740.625]_{2008} + [8175.5/10293.88]_{2009} + [2953.125/20594.06]_{2010}$

$= [10.75105]_{2008} + [0.79421]_{2009} + [0.143397]_{2010}$

Overall $PBP_{App\text{-}Engg}$ = (7962.5+8175.5+ 2953.125)/ ( 740.625+10293.88+20594.06)
$PBP_{App\text{-}Engg}$ = 31628.57/31628.56 =1

Year wise $PBP_{Cor\text{-}Engg}$ = [ Cost/ (cash inflows-cash outflows]$_{2007}$ + [ Cost/ (cash inflows-cash outflows]$_{2008}$ + [ Cost/ (cash inflows-cash outflows]$_{2009}$ + [ Cost/ (cash inflows-cash outflows]$_{2010}$

$PB_{Cor\text{-}Engg}$ = (Cost $_{Domain\_Engg}$ + Cost $_{App\_Engg}$) / [ (cash inflows-cash outflows) $_{Domain\_Engg}$ + (cash inflows-cash outflows) $_{App\_Engg}$]

$= [3550/-3550]_{2007} + [(3960+7962.5)/(2200+740.625)]_{2008} + [(4419.25+8175.5)/(2483.25+10293.88)]_{2009} + [(4933.913+2953.125)/(2804.313+20594.06)]_{2010}$

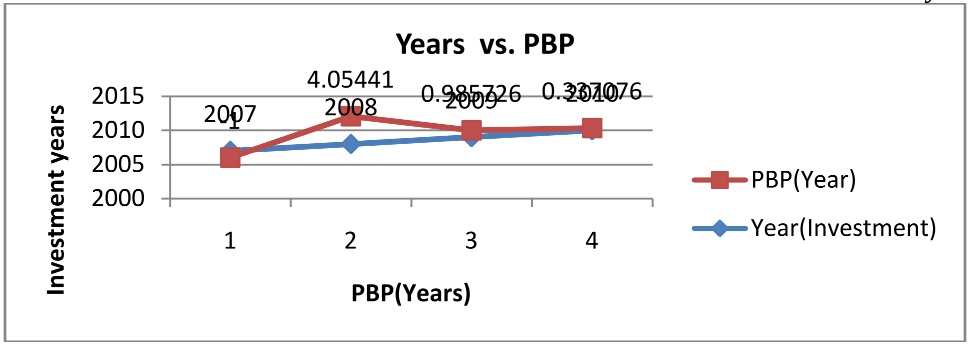
$= [-1]_{2007} + [4.05441]_{2008} + [0.985726]_{2009} + [0.337076]_{2010}$

Overall $PBP_{Cor\text{-}Engg}$ = (16863.16+31628.57)/( 9437.563 +31628.56)
= 48491.73/41066.12
= 1.180821

Table.6: PB (in years)

| For Year | **Component _ Engg. Cycle** | **Domain_ Engg. Cycle** | **Application _ Engg. Cycle** | **Corporate_ Engg. Cycle** |
|---|---|---|---|---|
| 2007 | -1 | -1 | | *-1* |
| 2008 | 0.8 | 1.8 | 10.75105 | 4.05441 |
| 2009 | 0.8 | 1.779623 | 0.79421 | 0.985726 |
| 2010 | 0.8 | 1.759402 | 0.143397 | 0.337076 |

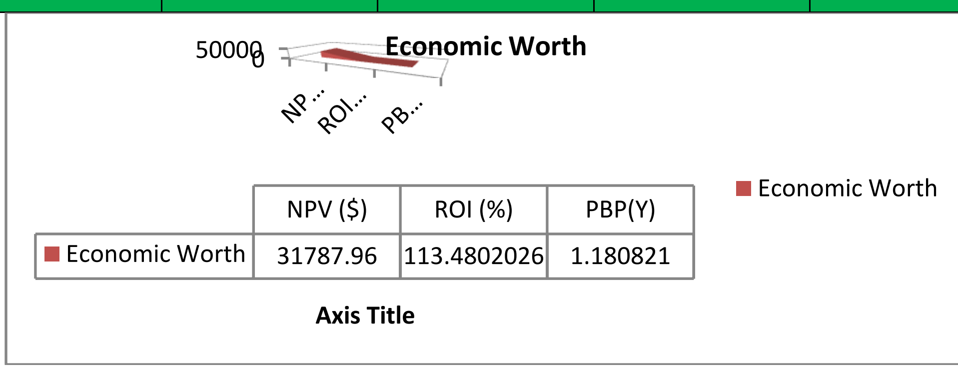



**Graph.3**

Results of used economic functions(NPV,ROI,PBP) as summarized in Table.4 and Graph.4 indicate that proposed reuse scheme would be worthwhile for the corporation for all reuse cycles after a period of one year.

Table.4:Corporation Economic worth after 4 years

| Economic function | **Component _ Engg. Cycle** | **Domain_ Engg. Cycle** | **Application _ Engg. Cycle** | **Corporate_ Engg. Cycle** |
|---|---|---|---|---|
| NPV ($) | 11554.22 | 8438.918 | 26349.05 | 31787.96 |
| ROI (%) | 87.86237 | 227.2926 | 56.92759776 | 113.4802026 |
| PBP (Years) | 1.282905 | 1.786813 | *1* | 1.180821 |




**Graph.4**

## IV. Conclusion

Proposed reuse model require initial investment but recover it in a very short period (one year). NPV is positive for all cycle after a period of one year that is considered more reliable than other economic functions and ROI is a derivative of NPV. So these investment appraisal techniques are sufficient to take decision about investment in said reuse program for an organization . All economic analysis technique results that proposed reuse scheme is beneficial and worthwhile for the corporation.

## V. Future Work

To gain more profit proposed reuse model will be extended for a long period by increasing reuse artefacts.

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