Mega Project Cost Benefit Analysis
Merced River Crossing Project

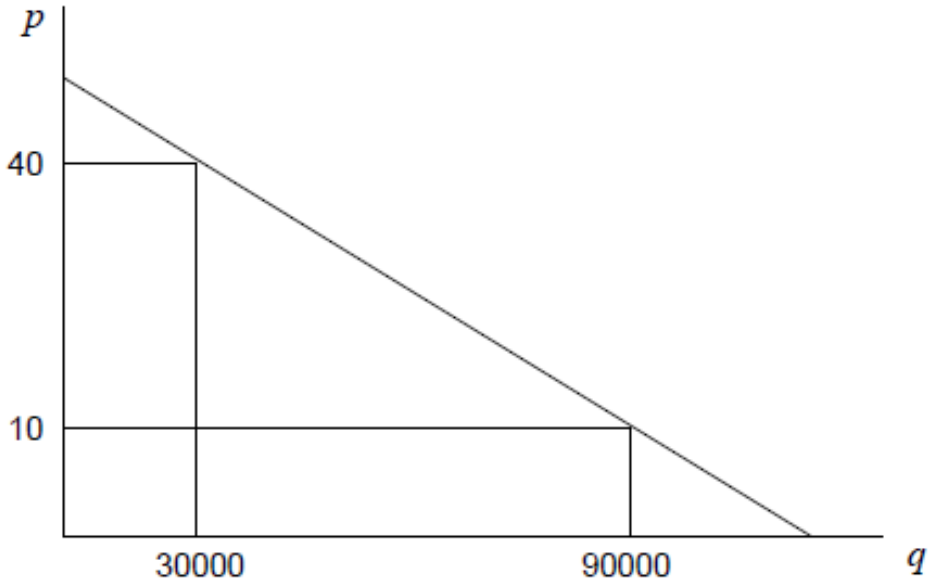
- Dharav Shah

1. Introduction

The government is considering constructing a bridge over the Merced River. The river can be currently crossed only operated by a ferry boat which is operated by a private firm. The main objectives of this project are to reduce the congestion and the time it takes to cross by ferry. This is a bridge, transit, highway, and pedestrian improvement project that will eventually decrease driving times and lead to measurable time savings and increase safety for both vehicles and maritime traffic. Construction of this bridge is expected to take two years to complete.

The private ferry firm currently charges $40 per vehicle crossing while the operating costs are $35 per crossing. It amounts to 30,000 crossings per year. This service will be closing when the bridge is completed, and the firm will be selling the ferry for scrap for $100,000. As previously mentioned, construction will take two years and the costs are estimated to be $11m in year 1 and $11m in year 2. These costs occurring will be funded out of the general tax revenue. The marginal cost of funds from taxation currently estimated to be 1.2. As announced, the bridge is expected to last forever.

Yearly maintenance costs are estimated to be $10 per crossing and this cost will be financed by a toll of $10 per crossing. The estimated number of yearly crossings at this price is 90,000.



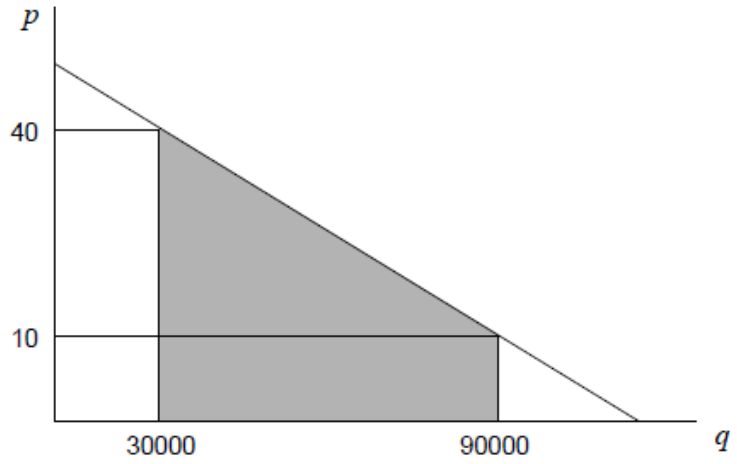
Demand curve of crossings.

2. Potential Impacts

The impacts of these project going through would be

- Increase in the number of crossings.
- Costs savings on ferry costs will be eliminated
- Scrapping of the ferry by the operating firm.
- Construction and maintenance costs
- Government finances that is the cost of funds.

This is the only reported project with the quantitative impacts given above. When you monetize all the impacts you see that there are 60,000 additional crossings per year. Below is the value of the crossings.



The value of the additional crossings is (10 x 60,000) + (30 x 60,000)/2 = **$1.5m**

Price of crossing by ferry is $40 but the cost of crossing is just $35 hence,

35 x 30,000 = **$1.05m**

Scrap value is **$100,000**

Above were the benefits of the project.

Construction costs are **$11m** in each of year 1 and 2.

Maintenance costs are **$900,000** per year in year 3 and every year thereafter.

These are costs of the project.

The impact of government finances that is the cost of funds is as follows

$m	year 1	year 2	year 3 (+)
outlays			
construction	11	11	
maintenance			0.9
receipts			
tolls			0.9
net outlay	11	11	0
cost of funds	2.2	2.2	0

Cost of funds = 0.2 x $11m = **$2.2m**

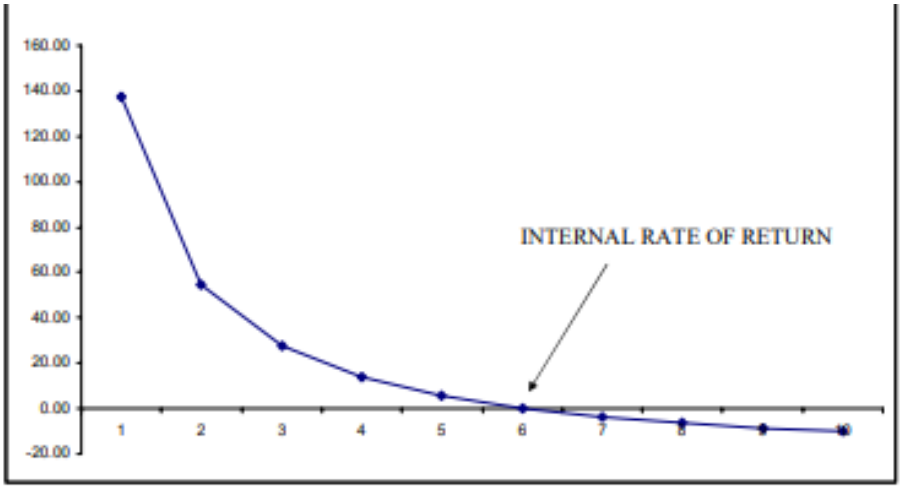
$m	year 1	year 2	year 3	year 4(+)
benefits				
new crossings			1.50	1.50
cost savings			1.05	1.05
ferry scrap value			0.10	
total benefits			2.65	2.55
costs				
construction	11.00	11.00		
maintenance			0.90	0.90
cost of funds	2.20	2.20		
total costs	13.20	13.20	0.90	0.90
net benefits	**-13.20**	**-13.20**	**1.75**	**1.65**

Now we will calculate the net present value and further the distribution of costs and the winners and losers.

3. **Outcomes**

$$NPV = -13.2 - \frac{13.2}{(1+r)} + \frac{1.75}{(1+r)^2} + \frac{\left[\frac{1.65(1+r)}{r}\right]}{(1+r)^3}$$

r	1	2	3	4	5	6	7	8	9	10
NPV	137.20	54.84	27.48	13.86	5.75	0.38	-3.42	-6.24	-8.41	-10.12



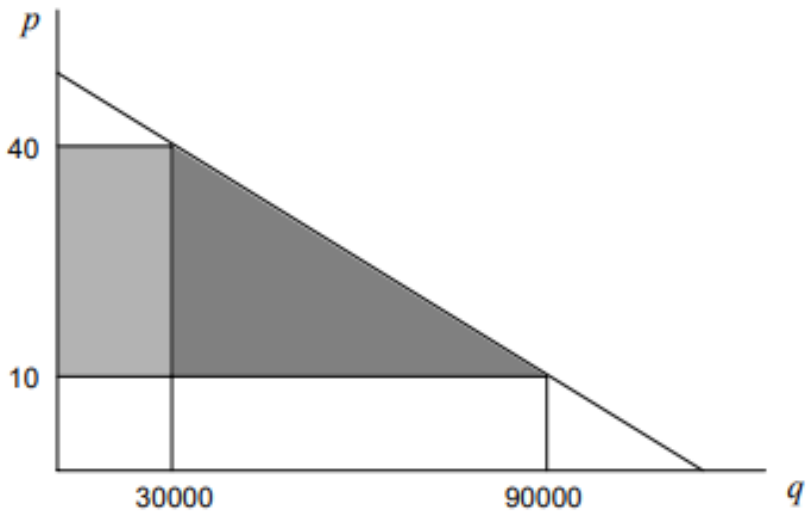
As we see above how the net present value changes over the years.

Now, we identify the distribution of costs and benefits.

a. Bridge Users

There is a gain in the consumer surplus after year 3.

(30 x 30,000) + (30 x 60,000)/2 = **$1.8m**.



Present value gain to bridge users

$$G_B = \frac{\left(1.8\left(\frac{1+r}{r}\right)\right)}{(1+r)^2}$$

b. Ferry Operator

As this will be closed from year 3. It is a loss of producer surplus

(40-35) x 30,000 = $150k. So, loss occurs in year 3 and every year thereafter.

However, it was decided that the ferry would be sold to scrap. Thus, the net loss to the private firm in present value terms is

$$L_F = \frac{\left(0.15\left(\frac{1+r}{r}\right) - 0.1\right)}{(1+r)^2}$$

c. Taxpayers

Construction costs plus the associated cost of funds in year 1 and 2. Present value of this loss is

L = 13.2 + (13.2/1+r).

$m (present value)	at 2%	at 5%	at 7%
winners			
bridge users	88.23	34.29	24.03
losers			
ferry operator	7.25	2.77	1.92
taxpayers	26.14	25.77	25.54
aggregate impact	**54.84**	**5.75**	**-3.43**

These comparisons help in proving that what we did was right.

4. Optimal Toll

As we see ordinarily, we would expect social surplus to be maximized when price is set equal to marginal cost. In this case, we have done the same of setting the toll equal to the marginal maintenance cost which is $10.

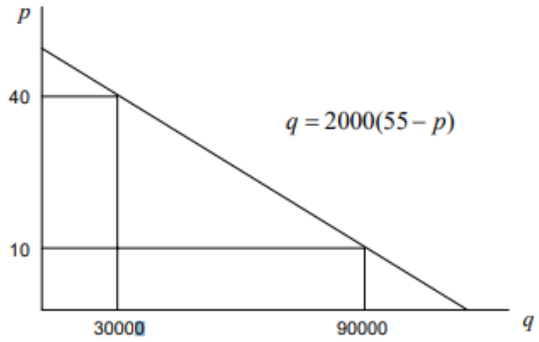
However, there is a significant cost of funds associated with taxpayer financing of construction costs. There obviously is some benefit from reducing that cost of funds by raising revenue from the toll beyond the amount that will cover the cost of maintenance.

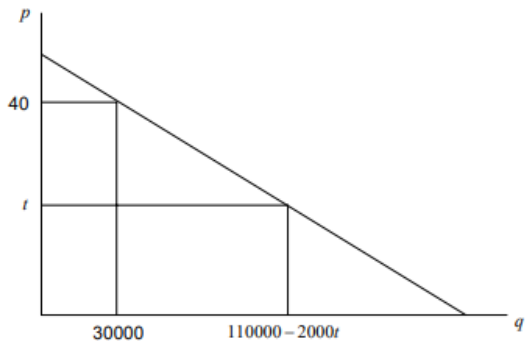
To determine the optimal toll, we first need to make toll a variable, and express NPV in terms of the toll. Later, the toll can be chosen to maximize NPV.

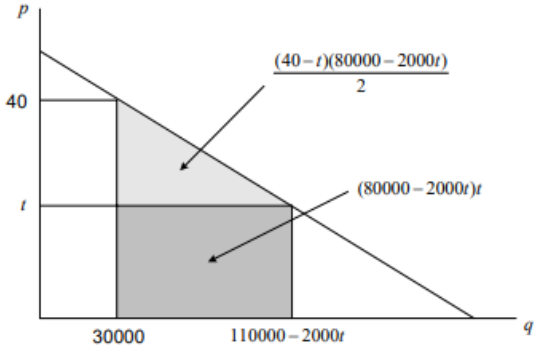
Some of the components of the NPV calculation that vary with the toll

- Value of new crossings
- Maintenance costs
- Revenue raised (cost of funds)

We start by deriving the equation for demand for crossings and after that the number of crossings as a function of the toll.







Value of new crossings.

$$V = (80000 - 2000t)\left(t + \frac{40 - t}{2}\right)$$

$$= 1600000 - 1000t^2$$

$$= \left(1.6 - \frac{t^2}{1000}\right) million$$

Maintenance costs

$$M = 10q(t)$$

$$= 10(110000 - 2000t)$$

$$= \left(1.1 - \frac{2t}{100}\right) million$$

Toll Revenue

$$T = tq(t)$$

$$= t(110000 - 2000t)$$

$$= \left(0.11t - \frac{2t^2}{1000}\right) million$$

$m	year 1	year 2	year 3 (+)
outlays			
construction	11	11	
maintenance			0.9
receipts			
tolls			0.9
net outlay	11	11	0
cost of funds	2.2	2.2	0

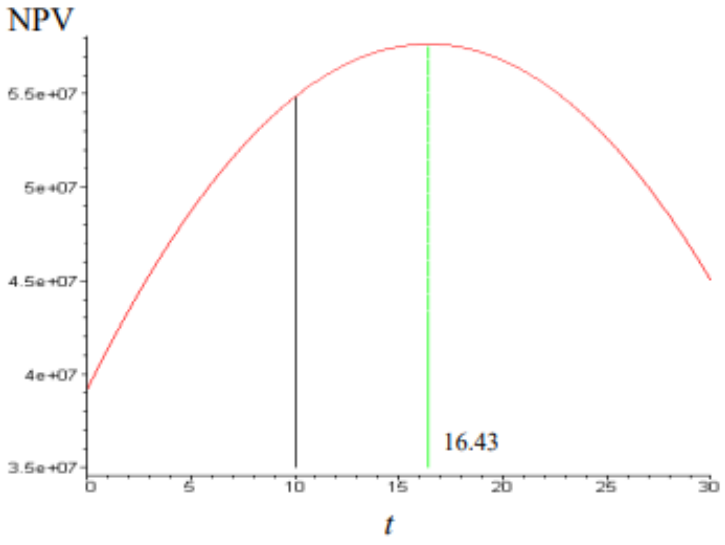
$\left(1.1 - \frac{2t}{100}\right)$

$\left(0.11t - \frac{2t^2}{1000}\right)$

$$\left(1.6-\frac{t^2}{1000}\right)$$

$m	year 1	year 2	year 3	year 4(+)
benefits				
new crossings			1.50	1.50
cost savings			1.05	1.05
ferry scrap value			0.10	
total benefits			2.65	2.55
costs				
construction	11.00	11.00		
maintenance			0.90	0.90
cost of funds	2.20	2.20		
total costs	13.20	13.20	0.90	0.90
net benefits	**-13.20**	**-13.20**	**1.75**	**1.65**

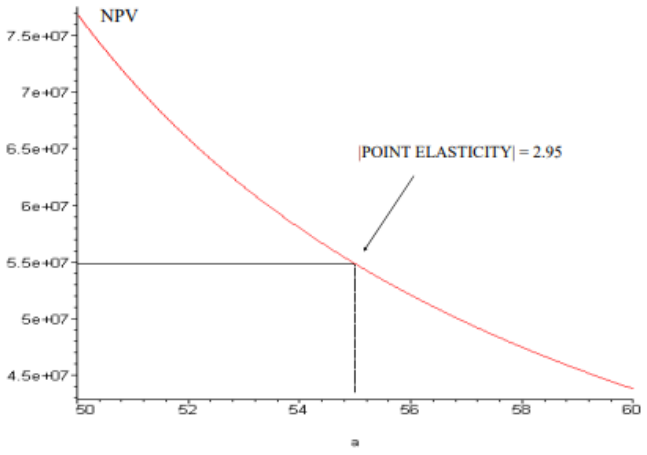
We can now experiment with different values of *t* to determine the toll that maximizes NPV.



Experiment		
	Policy 1	Variant
Toll	10	16.43
MCF	1.2	1.2
Surplus Changes (2%)		
NPV	54.84	57.67
Winners		
Bridge Users	88.24	61.89
Losers		
Ferry Operator	7.26	7.26
Taxpayers	26.14	1.83

5. Sensitivity Analysis

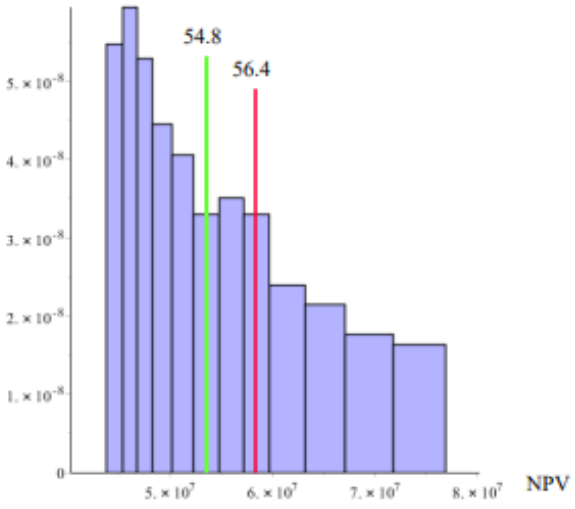
To illustrate how sensitive is the NPV within the specified range of *a*, assume t = 10 and r = 0.02



his

This shows that the NPV is not linear rather it is strictly convex.

In Simulation, let us draw n = 10,000 values from a uniform distribution on (50,60) and calculate the NPV and we will then report it on a histogram.



As we see here in the histogram, expected NPV is calculated as the mean of the 10,000 values generated. This mean is highlighted in the above figure in red which is $56.4m and when a = 55, its highlighted in green which is $54.8m.

Here, the NPV is a strictly convex function of a that is why the expected NPV is greater than the NPV evaluated at the expected value of a.

6. Conclusion

This was a very simple example of the Cost Benefit Analysis which I performed using Excel and a little bit of python. More analysis can still be conducted using this data which is calculating the values using uncertainty of the river crossings.

But according to the current analysis building this river crossing on the Merced River is a go but in real life situations more data would be required and alternate solutions to get to the optimal answer to select a project.