Transportation Economics and Decision Making

Lecture-6

Internal Rate of Return Method

- Three alternatives are considered for improving a street intersection. The annual dollar savings of each alternative is shown below. Considering 25 years of service life of each, which alternative produces highest return. Use IRR technique to justify your answer.

Alternative	Total Cost	Annual Benefits
1	10,000	800
2	12,000	1000
3	19,000	1400

Solution

Alternative	Total Cost	Annual Benefits	Annual Cost	Difference	IRR		Incremental Benefit	Incremental Cost	Difference	IRR	Winner
1	10,000	800	571.43	228.57	6.25						
2	12,000	1000	685.71	314.29	6.68		200	114	86	8.78%	A-2
3	19,000	1400	1085.71	314.29	5.38		400	400	0	2.96%	A-2

Analysis Based on Total Cost

Alternative	Capital Cost	Annualized Cost	Annualized Maintenance Cost	Annual Highway Cost	Annual Road User Cost	Total Annual Cost
A-1	-	-	60	60	2,200	2,260
A-2	1,500	121	35	156	1,920	2,076
A-3	2,000	161	30	191	1,860	2,051
A-4	3,500	282	40	322	1,810	2,132
B-1	3,000	242	30	272	1,790	2,062
B-2	4,000	322	20	342	1,690	2,032
B-3	***5,000***	***403***	***30***	***433***	***1,580***	***2,013***
B-4	6,000	484	40	524	1,510	2,034
B-5	7,000	564	45	609	1,480	2,089
C-1	5,500	443	40	483	1,620	2,103
C-2	8,000	645	30	675	1,470	2,145
C-3	9,000	725	40	765	1,400	2,165
C-4	11,000	886	50	936	1,340	2,276

Analysis Based on Benefit Cost Ratio (Compare do nothing with all alternatives)

Alternative	Capital Cost	Annualized Cost	Annualized Maintenance Cost	Annual Highway Cost	Annual Road User Cost	Total Annual Cost	User Benefits Compared to A-1	Highway Costs Compared to A-1	B/C Ratio
A-1	-	-	60	60	2,200	2,260			
A-2	1,500	121	35	156	1,920	2,076	280	96	2.92
A-3	2,000	161	30	191	1,860	2,051	340	131	2.59
A-4	3,500	282	40	322	1,810	2,132	390	262	1.49
B-1	3,000	242	30	272	1,790	2,062	410	212	1.94
B-2	4,000	322	20	342	1,690	2,032	510	282	1.81
B-3	5,000	403	30	433	1,580	2,013	620	373	1.66
B-4	6,000	484	40	524	1,510	2,034	690	464	1.49
B-5	7,000	564	45	609	1,480	2,089	720	549	1.31
C-1	5,500	443	40	483	1,620	2,103	580	423	1.37
C-2	8,000	645	30	675	1,470	2,145	730	615	1.19
C-3	9,000	725	40	765	1,400	2,165	800	705	1.13
C-4	11,000	886	50	936	1,340	2,276	860	876	0.98

Does not mean A-2 is the most preferred alternative

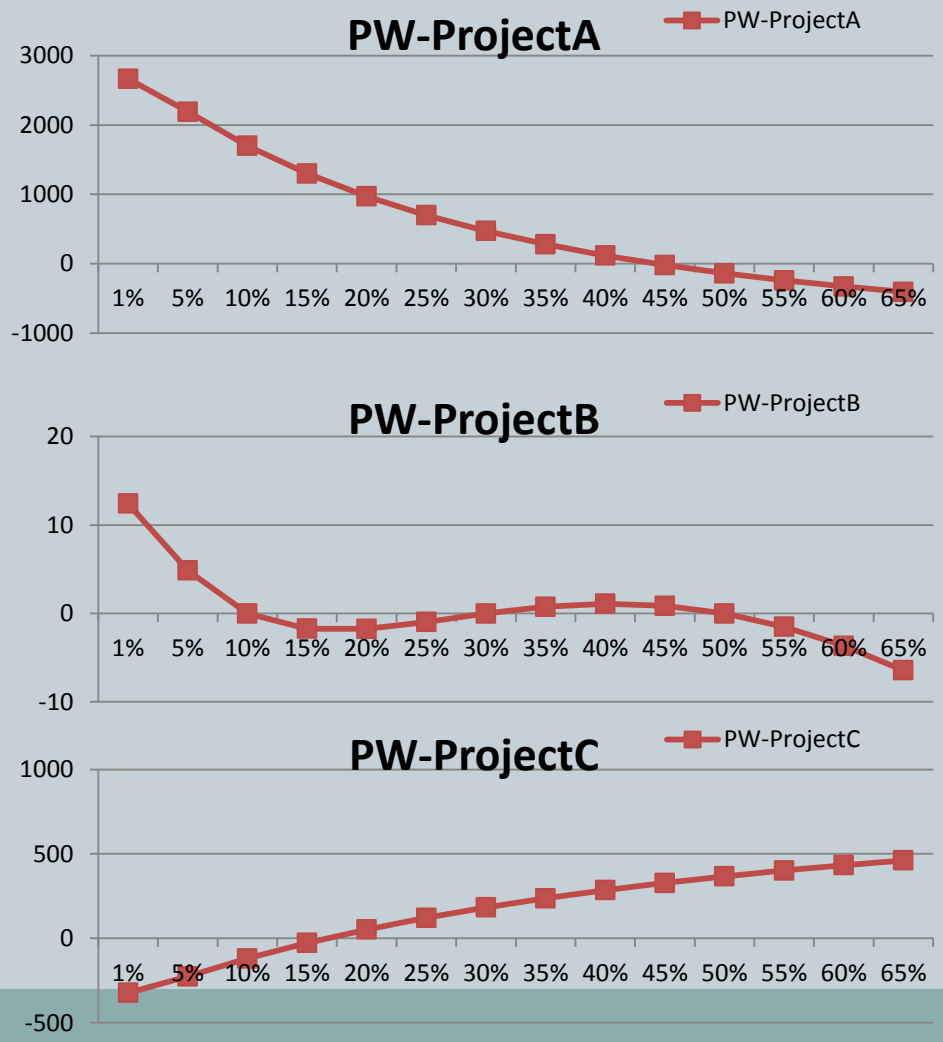
Incremental B/C Ratio

Alternative	Annual Highway Cost	Annual Road User Cost	Comparison	Incremental Benefit	Incremental Cost	Incremental B/C	Decision
A-1	60	2,200					
A-2	156	1,920	A-1	280	96	2.92	**A-2**
A-3	191	1,860	A-2	60	35	1.70	**A-3**
A-4	322	1,810	A-3	50	131	0.38	**A-3**
B-1	272	1,790	A-3	70	81	0.87	**A-3**
B-2	342	1,690	A-3	170	151	1.12	**B-2**
B-3	433	1,580	B-2	110	91	1.21	**B-3**
B-4	524	1,510	B-3	70	91	0.77	**B-3**
B-5	609	1,480	B-3	100	176	0.57	**B-3**
C-1	483	1,620	B-3	(40)	50	-0.80	**B-3**
C-2	675	1,470	B-3	110	242	0.45	**B-3**
C-3	765	1,400	B-3	180	332	0.54	**B-3**
C-4	936	1,340	B-3	240	504	0.48	**B-3**

Multiple IRR

Year	Project-A	Project-B	Project-C
0	-1,000	-1,000	1,000
1	-500	3,900	-450
2	800	-5,030	-450
3	1,500	2,145	-450
4	2,000		

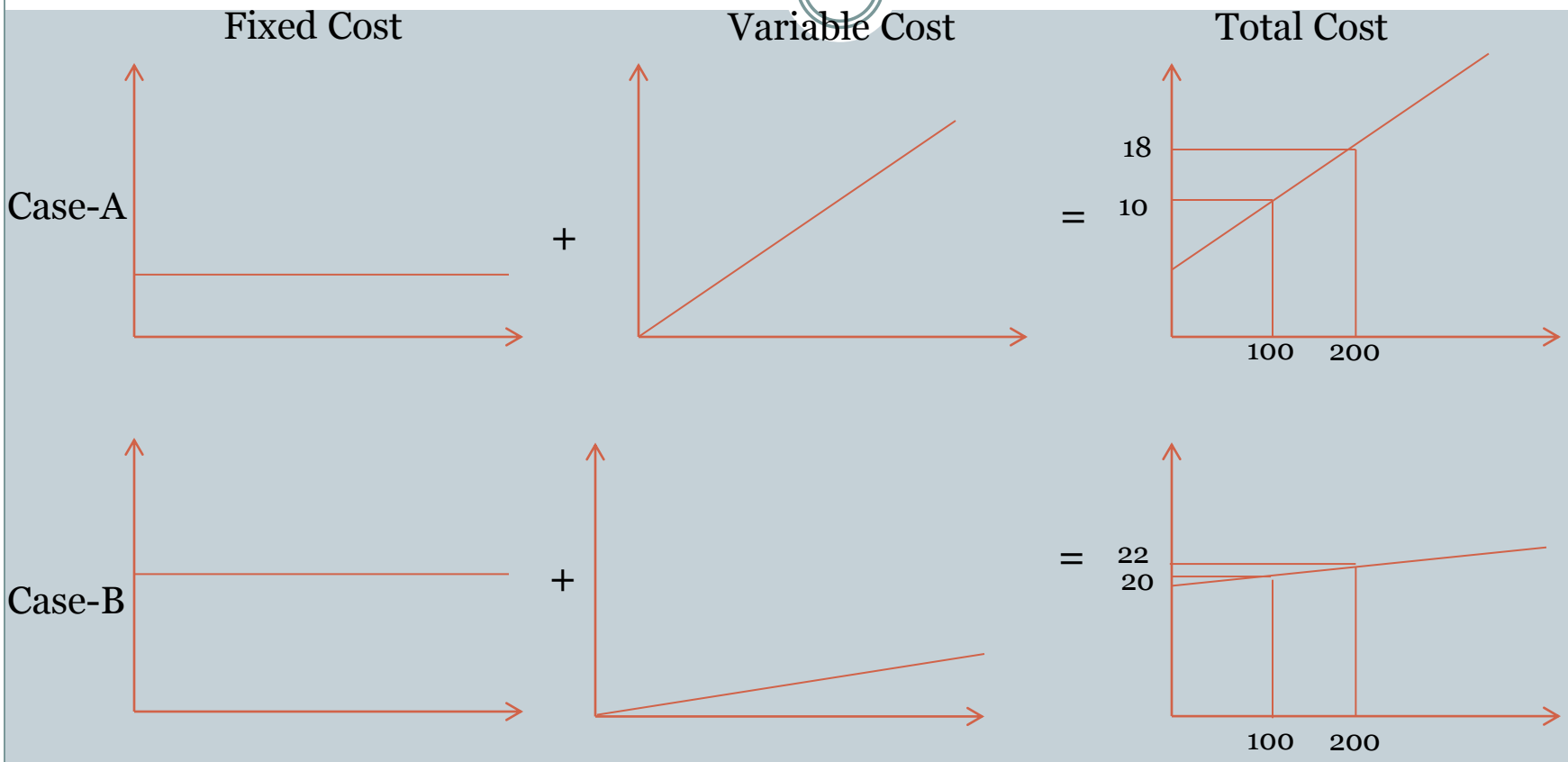
Case of Multiple IRRs



Costs

- The total cost of owning and operating a facility is broken into
  - Fixed cost
  - Variable cost
  - Total cost = Fixed Cost + Variable Cost
- Fixed cost does not depend on production levels or degree of utilization
  - Purchase price
- Variable cost depends on degree of production or utilization
  - Depends on use (increased wear and tear)

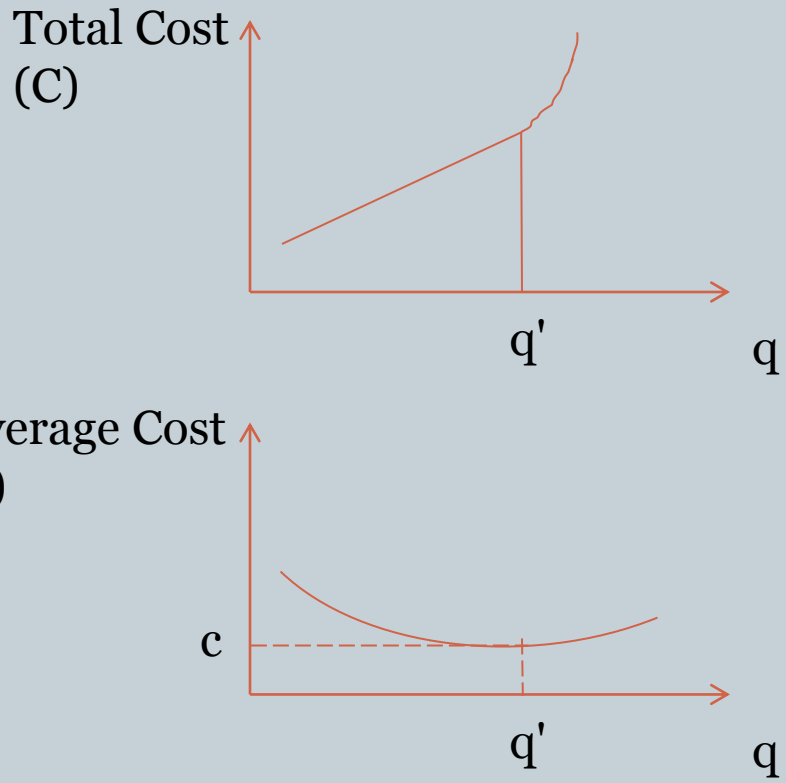
Fixed and Variable Cost



Case-A: When production is doubled unit cost drops from $0.10 to $0.09 (10% reduction)
Case-B: When production is doubled unit cost drops from $0.20 to $0.11 (45% reduction)

Economy of Scale

- Economy of scale is defined as the decrease in average cost as the output increases.



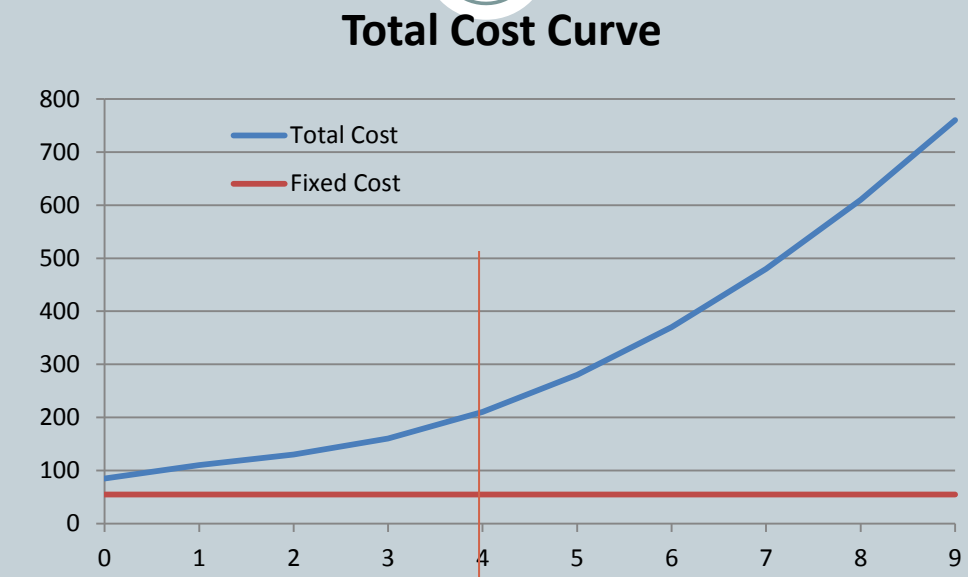
Example-1

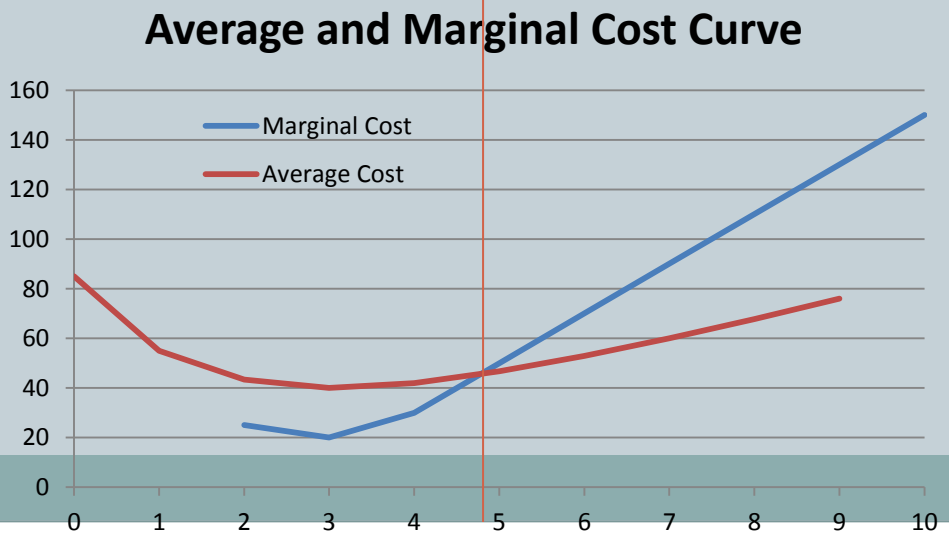
Number of Wagons	Fixed Cost	Varibale Cost
0	0	0
1	55	30
2	55	55
3	55	75
4	55	105
5	55	155
6	55	225
7	55	315
8	55	425
9	55	555
10	55	705

Example-1

Number of Wagons	Fixed Cost	Varibale Cost	Total Cost	Average Cost	Marginal Cost
0	0	0	0	0	0
1	55	30	85	85.00	
2	55	55	110	55.00	25
3	55	75	130	43.33	20
4	55	105	160	40.00	30
5	55	155	210	42.00	50
6	55	225	280	46.67	70
7	55	315	370	52.86	90
8	55	425	480	60.00	110
9	55	555	610	67.78	130
10	55	705	760	76.00	150

Example-1


Total Cost Curve
Total Cost
Fixed Cost
800
700
600
500
400
300
200
100
0
0
1
2
3
4
5
6
7
8
9


Average and Marginal Cost Curve
Marginal Cost
Average Cost
160
140
120
100
80
60
40
20
0
0
1
2
3
4
5
6
7
8
9
10

Example-2

- A city is considering building one of the following two types of transit systems, Type A and Type B. Type A is a conventional high-speed bus system on a freeway network, and Type B is an advanced, energy-efficient, light-trail transit system on a fully controlled-access network.

	Type A	Type B
Initial Cost	$\$45 \times 10^6$	$\$80 \times 10^6$
Project Life	20 years	20 years
Operating Cost	\$0.25/pass. mile	\$0.18/pass. mile
Ridership	180,000 Pass. Miles/day	216,000 Pass. Miles/day

(a) Using a discount rate of 6% per year, compute the fixed cost, variable cost and total cost of the two systems on an annualized basis, as well as the unit cost/pass. mile. Which system should be built?

(b) Assuming an average 15-mile trip length per passenger, and a 30% subsidy, what should be the fare/passenger for the recommended system? Also compute the minimum demand for the Type B system in order for it to be more cost efficient than Type A. Assume demand for Type B to be 20% higher than that for Type A.

Question

- A transportation company hauling goods by truck has a cost function, $C = 15q^{1.25}$, where C is the total cost, and q is the supply.
  - Determine the average cost, and marginal cost
  - What is the elasticity
  - Is there an economy of scale

Answer

- Average cost = $C/q = 15q^{1.25}/q = 15q^{0.25}$
- Marginal cost = $dc/dq = 15*1.25q^{0.25} = 18.75q^{0.25}$
- Elasticity = MC/AC = 1.25
- EOS does not exist because average cost increases with increase in q