KG REDDY College of Engineering & Technology

Economic Analysis

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- http://www.dot.ca.gov/hq/tpp/offices/ote/Benefit_Cost/index.html

- A systematic process for calculating and comparing benefits and costs of a project for two purposes:
  - to determine if it is a sound investment (justification/feasibility)
  - to see how it compares with alternate projects (ranking/priority assignment)
- **What You Will Find on This Website**
  - How to define the problem that the project addresses and set up the analysis
  - How to measure and value benefits and costs of transportation projects
  - Tools for calculating benefit-cost measures, dealing with uncertainty, and estimating and valuing benefits and costs that do not have an established monetary value
  - Benefit-cost models and links to model sites
  - Case studies of benefit-cost analyses for transportation projects
  - How to interpret and present results
  - References

Outline

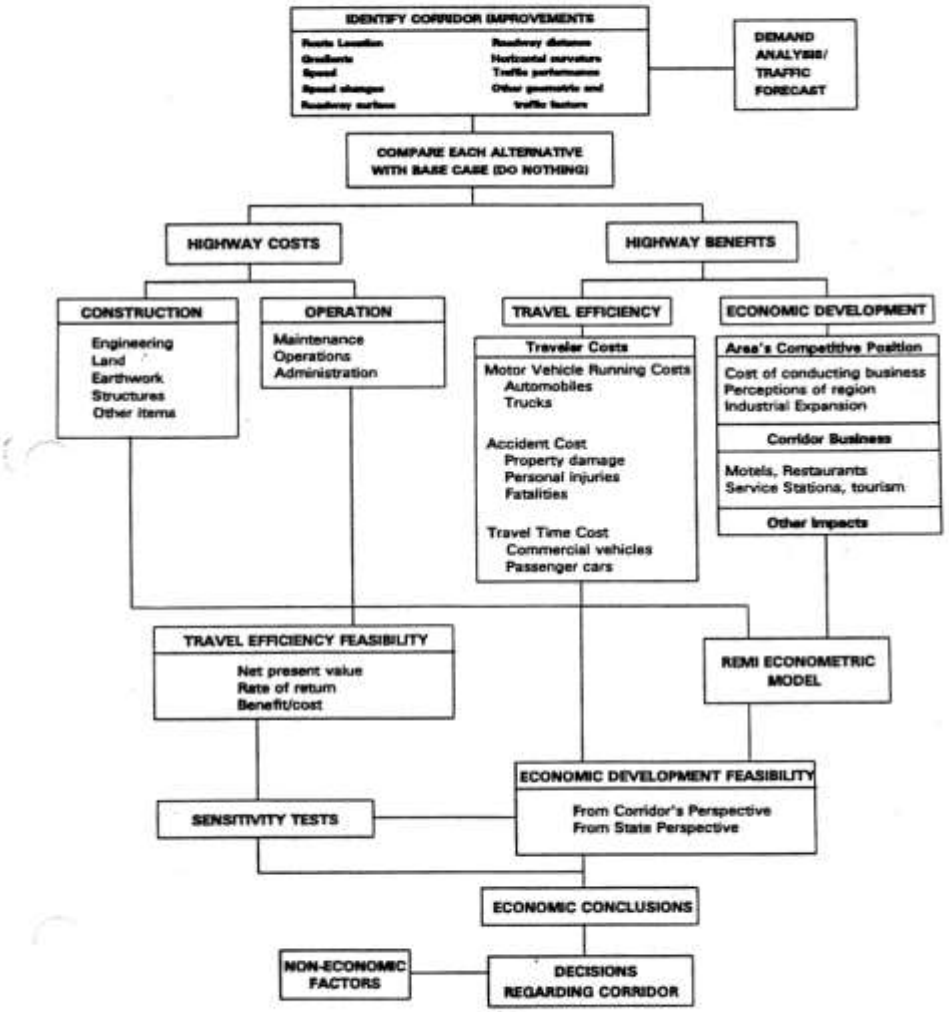
- Economic basis
- General procedure
- Estimating Costs
- Estimating Benefits
- Comparing costs and benefits

Economic Basis

- A project has economic value if it increases prosperity and incomes (is that all?)
- This can happen in two ways
  - Increased output requires more resources (e.g., attracting business)
  - Increased efficiency (lower cost of production)
  - *Never measured but quite important – the reorganization of production!*
- Too much investment wastes resources, too little stifles business and productivity
- Economic analysis doesn't include everything

Exhibit 1-2

ECONOMIC EVALUATION PROCESS



1-9

General Procedure

Summary of chart on slide 3

1. ID project and options
2. Select base case
3. Traffic analysis and forecasts
4. Estimate capital and operations costs
5. Calculate travel efficiency cost savings
6. Calculate feasibility from user perspective

General Procedure

Summary of chart on slide 3 (cont.)

7. Estimate economic development impacts
8. Calculate feasibility from economic development perspective
9. Conduct sensitivity analysis
10. Interpret results
11. Include economic analysis with non-economic factors in making decision

Estimating Costs

- Capital cost
  - Engineer's estimate is best (See summary of bid prices and example plans)
  - Can use unit cost from experience (see example)
  - See list of typical elements, next page
  - Do not include sunk costs
  - Allow for a salvage (residual) value and discount it (see next page)

Exhibit 2-1

TYPICAL HIGHWAY CAPITAL COST ITEMS

- Planning and environmental studies
- Preliminary engineering
- Right-of-way
  - Land
  - Improvements
  - Relocation of structures
  - Damages
- Environmental mitigation
- Construction engineering
- Roadway construction
  - Clearing the rights-of-way
  - Earthwork and grading
  - Drainage and related structures
  - Roadway base and surface
  - Roadwide development
  - Miscellaneous structures
- Major structures
- Traffic service facilities

Cost Element	Useful Life
Right-of-Way	infinite
Bridges and Structures	60 years
Earthworks	100 years
Road Base	50 years
Pavement, Shoulders	30 years

Estimating Costs

- Operations and maintenance cost

Exhibit 2-3

UNIT MAINTENANCE COSTS

1992

	MAINTENANCE COST PER ROAD MILE PER YEAR			
	4-Lane Paved	2-Lane Paved	Treated Surface	2-Lane Gravel Surface
Interstate	$16,000	--	--	--
Arterials	11,500	$8,000	$2,770	--
Other Primary	5,000	3,650	2,770	$1,940
Municipal	9,000	7,000	4,000	2,000
Secondary	5,000	1,830	2,770	1,940

Source: Iowa DOT

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Cost Side: Preparing costs for B/C

Exhibit 2-4

EXAMPLE LIFE-CYCLE COST TOTALS

Ready for Use in Benefit-Cost Analysis

From U.S. 20 Corridor Study

($000)

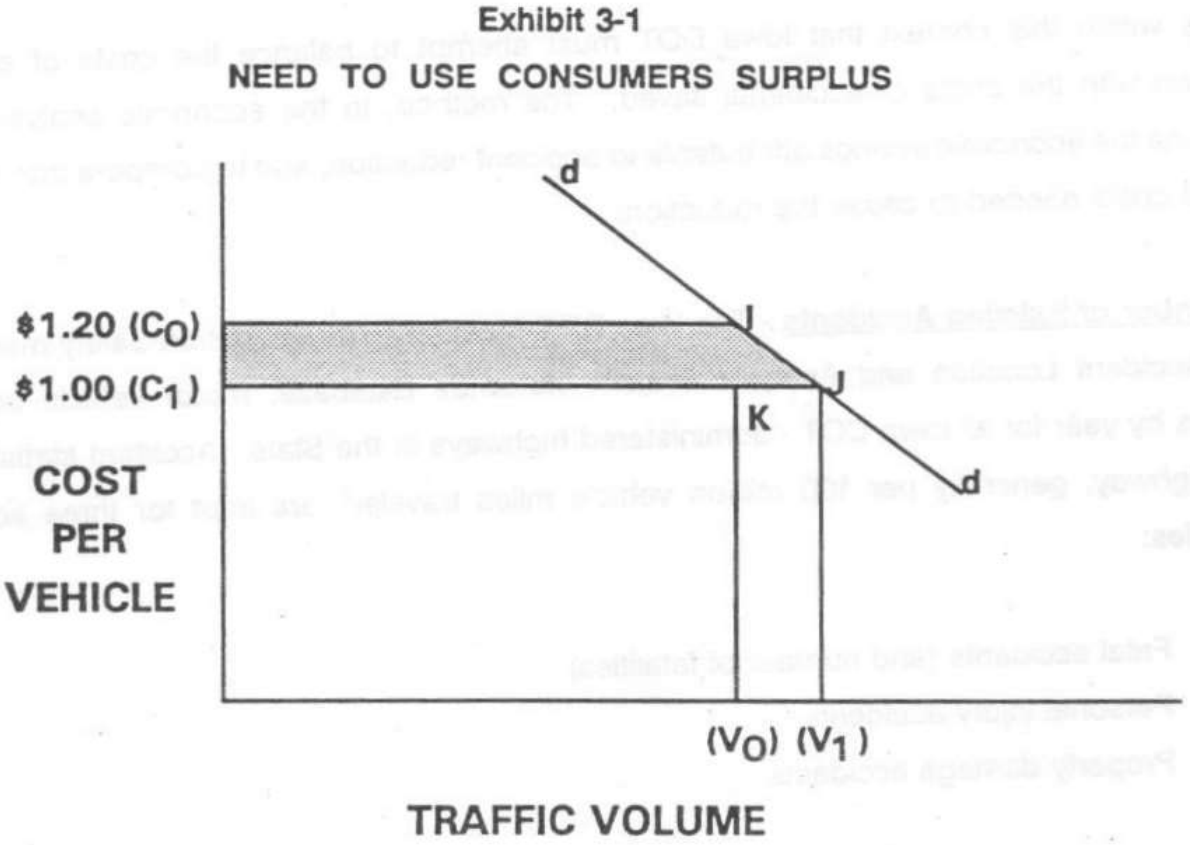
	COSTS BY YEAR			TOTAL COSTS		
Year	Capital	Maintenance	Residual	Not Discounted	Discounted at 6%	Present Worth Factor
1992	173,210.0		$0.0	$173,210.0	$173,210	1.0000
1993		533.7	0.0	533.7	503	0.9434
1994		533.7	0.0	533.7	475	0.8900
1995		533.7	0.0	533.7	448	0.8396
1996		533.7	0.0	533.7	423	0.7921
1997		533.7	0.0	533.7	399	0.7473
1998		533.7	0.0	533.7	376	0.7050
1999		533.7	0.0	533.7	355	0.6651
2000		533.7	0.0	533.7	335	0.6274
2001		533.7	0.0	533.7	316	0.5919
2002		533.7	0.0	533.7	298	0.5584
2003		539.6	0.0	539.6	284	0.5268
2004		545.6	0.0	545.6	271	0.4970
2005		551.5	0.0	551.5	259	0.4688
2006		557.4	0.0	557.4	247	0.4423
2007		563.4	0.0	563.4	235	0.4173
2008		569.3	0.0	569.3	224	0.3936
2009		575.2	0.0	575.2	214	0.3714
2010		581.1	0.0	581.1	204	0.3503
2011		593.0	0.0	593.0	196	0.3305
2012		604.9	0.0	604.9	189	0.3118
2013		616.7	0.0	616.7	181	0.2942
2014		628.6	0.0	628.6	174	0.2775
2015		640.4	0.0	640.4	168	0.2618
2016		652.3	0.0	652.3	161	0.2470
2017		664.2	0.0	664.2	155	0.2330
2018		676.0	0.0	676.0	149	0.2198
2019		693.8	0.0	693.8	144	0.2074
2020		711.6	0.0	711.6	139	0.1956
2021		729.4	0.0	729.4	135	0.1846
2022		759.0	53,554.0	759.0	132	0.1741
Total	$173,210.0	$17,790.0	Benefit	$191,000.0	$180,997	

Summary: Estimating Costs

- Capital cost
- Operations and maintenance cost
- Preparing costs (time value) for B/C

Estimating Benefits

- Analysis procedure



	BASE CASE "O"	ALTERNATIVE #1
Traffic Volume:		
Common Traffic	1,000	1,000
Diverted/Generated	0	300
Total Traffic	1,000	1,300
Cost Per Vehicle:		
Common	$1.20	$1.00
Diverted/Generated	----	$1.00

CONSUMERS SURPLUS BENEFIT

$= 1/2\ (C_o - C_1)\ (V_o + V_1)$

$= 1/2\ (\$1.20 - 1.00)\ (1,000 + 1,300)$

$= 1/2\ (\$.20)\ (2,300)$

$= \$230$ benefit

LEAST COST BENEFIT

$= (C_o)\ (V_o) - (C_1)\ (V_1)$

$= (1.20)\ (1,000) - (\$1.00)\ (1,300)$

$= \$1,200 - \$1,300$

$= (\$100)$ benefit

Estimating Benefits

- Accident (Crash) cost savings
  - Years lost + direct costs
  - 1991 cost of fatality, $2,392,742 (Urban Institute) biased?
  - Willingness to pay (e.g., for a safety improvement)
  - Missouri and Kansas, $1.5M (1993), Iowa, $800,000 (2002)

Exhibit 3-3

ALTERNATIVE MONETARY VALUES OF ACCIDENTS

	MONETARY VALUES BY ACCIDENT TYPE		
	Fatal [d]	Injury [e]	Property Damage [e]
U.S. 20 Corridor Study (1992)[a]			
Per Accident	--	$16,500	$1,000
Per Fatality	$500,000	--	--
U.S. 63 Corridor Study (1991)[b]			
Per Accident	$1,700,000	$14,000	$3,000
Per Fatality	$1,500,000	--	--
Avenue of the Saints (1990)[b]			
Per Accident	$1,965,200	$16,700	$3,300
FHWA (1991)[c]			
Per Accident	$2,723,000	$70,000	$4,500
Per Fatality	$2,393,000	$46,000	$1,700(a)

(a) Based on Iowa DOT Bureau of Transportation Safety.
(b) Based on various FHWA sources.
(c) Based on 1991 study by the Urban Institute, RD-91-055.
(d) Cost per fatality (not cost per fatal accident).
(e) Cost per accident.

Exhibit 3-5

ACCIDENT RATES BY HIGHWAY TYPE

HIGHWAY TYPE	ACCIDENT RATE PER HMVM OF TRAVEL [a]		
	Fatalities	Injuries	Property Damage
Interstate	0.78	22.00	54.00
Expressway @ 65 mph	1.56	90.59	229.07
Expressway @ 55 mph	1.20	69.69	176.21
Existing 4-lane	2.32	117.00	286.00
New 2-lane	2.07	120.15	303.81
2-lane County Roads	2.48	130.00	310.00
2-lane Bypasses	2.11	121.50	307.22
2-lane Highway	2.34	135.00	341.36

(a) HMVM = hundred million vehicle miles of travel

SOURCE: U.S. 20 Corridor Study

Estimating Benefits

- Travel time savings
  - Factors
    - Size of time increment saved (100% for over 11 minutes)
    - Occupancy
    - Purpose
    - Willingness to pay

Exhibit 3-11

PER AUTOMOBILE HOUR TRAVEL TIME VALUE BY TRIP PURPOSE

U.S. 20 Corridor Study

Time Saving Increments (minutes)	Business Vehicles	Non-Business Vehicles	Weighted Average (30/70)
0 - 5	$ 7.75	$4.35	$ 5.37
6 - 10	11.63	6.53	8.06
11 or more	15.50	8.70	10.74

Time Saving Increments (minutes)	Two Lane with Bypasses	55 mph 4-Lane Expressway	65 mph 4-Lane Expressway
0 - 5	96.61%	73.60%	69.27%
6 - 10	3.38%	17.63%	15.26%
11 or more	0.01%	8.77%	15.47%
	100.00%	100.00%	100.00%
Weighted Average Per Vehicle Hour Value of Time	$5.46	$5.72	$6.32

Estimating Benefits

- Vehicle operating cost savings
  - Fuel, oil, maintenance, etc.
  - See Red book and many references

Economic Development Benefits

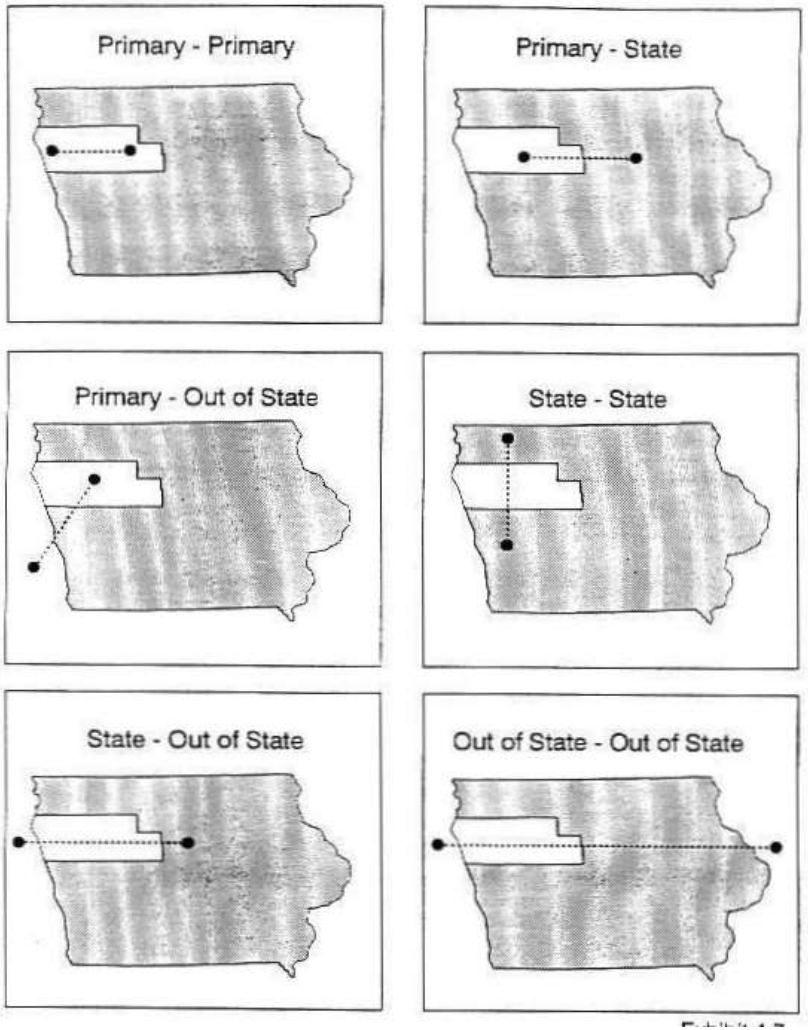
- Development principles and types
  - Corridor
  - State
  - Nation
  - Some indicators
    - Economic activity
    - Value added
    - Income
    - Employment
    - Population

Economic Development Benefits

- Four categories
  - Construction impact
  - Roadside expenditures
  - Competitive reposition
  - Non-business

Economic Development Benefits

- Economic models
  - Input/output (e.g., REMI)



Summary: Estimating Benefits

- Accident (Crash) cost savings
- Travel time savings
  - Auto
  - Truck
- Vehicle operating cost savings
- Economic Development Benefits
  - Development principles and types
  - Economic models

Comparing costs and benefits

- Life cycle approach
  - Choose base year
  - Include all present and future costs/benefits

Comparing costs and benefits

- Discount future costs and benefits
- Net present value
- Benefit/cost ratio
- Internal rate of return
- Choice of discount rate is tricky and VERY important over long time periods

Comparing costs and benefits

- Decision rules
  - Maximize net present value
  - Use incremental rate of return to compare projects (not just B/C compared to do-nothing)
  - Limited budgets affect choice of project (may not be overall best B/C or IROR)

Comparing costs and benefits

- Uncertainty, sensitivity and risks
  - Vary the following …
    - Discount rate
    - Capital costs (20%)
    - Traffic volumes (20%)
    - Crash values (use FHWA?)
    - Value of time (FHWA?)
    - Higher posted speed

Comparing costs and benefits

- Future research needed
  - Value of crashes
  - Agriculture impacts
  - Logistics impacts
  - Industrial location
  - REMI sub-state regions
  - Urban methods
  - VOC methods
  - Super 2 analysis

Summary: Comparing costs and benefits

- Life cycle approach
- Discount future costs and benefits
- Decision rules
- Uncertainty, sensitivity and risks
- Future research needed

Example

- See HRGreen Benefit/Cost Analysis Spreadsheet

Annual Safety Benefits

Year	AADT	Heavy Trucks	Passenger Cars	Existing Crash Cost	Proposed Crash Cost	Safety Benefits	Present Worth Safety Benefits
2001	28,850	1,700	27,150	$3,053,146	$3,053,146	$0	$0
2002	29,460	1,729	27,731	$3,117,701	$3,117,701	$0	$0
2003	30,070	1,758	28,312	$3,182,257	$3,182,257	$0	$0
2004	30,680	1,788	28,893	$3,246,812	$3,246,812	$0	$0
2005	31,290	1,817	29,473	$3,311,367	$3,311,367	$0	$0
2006	31,900	1,846	30,054	$3,375,922	$1,854,902	$1,521,020	$1,220,544
2007	32,510	1,875	30,635	$3,440,478	$1,890,372	$1,550,105	$1,190,319
2008	33,120	1,904	31,216	$3,505,033	$1,925,842	$1,579,191	$1,160,434
2009	33,730	1,933	31,797	$3,569,588	$1,961,312	$1,608,276	$1,130,916
2010	34,340	1,963	32,378	$3,634,143	$1,996,782	$1,637,361	$1,101,788
2011	34,950	1,992	32,958	$3,698,699	$2,032,252	$1,666,447	$1,073,071
2012	35,560	2,021	33,539	$3,763,254	$2,067,722	$1,695,532	$1,044,785
2013	36,170	2,050	34,120	$3,827,809	$2,103,192	$1,724,617	$1,016,945
2014	36,780	2,079	34,701	$3,892,364	$2,138,662	$1,753,703	$989,565
2015	37,390	2,108	35,282	$3,956,920	$2,174,132	$1,782,788	$962,657
2016	38,000	2,138	35,863	$4,021,475	$2,209,602	$1,811,873	$936,232
2017	38,610	2,167	36,443	$4,086,030	$2,245,072	$1,840,959	$910,298
2018	39,220	2,196	37,024	$4,150,585	$2,280,541	$1,870,044	$884,861
2019	39,830	2,225	37,605	$4,215,141	$2,316,011	$1,899,129	$859,926
2020	40,440	2,254	38,186	$4,279,696	$2,351,481	$1,928,215	$835,499
2021	41,050	2,283	38,767	$4,344,251	$2,386,951	$1,957,300	$811,580
2022	41,660	2,313	39,348	$4,408,806	$2,422,421	$1,986,385	$788,173
2023	42,270	2,342	39,928	$4,473,362	$2,457,891	$2,015,471	$765,276
2024	42,880	2,371	40,509	$4,537,917	$2,493,361	$2,044,556	$742,890
2025	43,490	2,400	41,090	$4,602,472	$2,528,831	$2,073,641	$721,012
						PW Safety =	$19,146,770

PW of Benefits =	$105,204,051
PW of Salvage Value =	$28,680,122
PW of Costs =	$96,200,167
B/C Ratio =	1.56
Net Present Worth =	$37,684,006