Project Evaluation and Programming I
Project Evaluation

presented to
MIT 1.201 Class

presented by
Lance Neumann
Cambridge Systematics, Inc.

November 20, 2008

Transportation leadership you can trust.

CAMBRIDGE SYSTEMATICS

Outline

- **Lecture 1 – Project Evaluation**
  - **Objectives of project evaluation**
  - **Review of basic concepts**
  - **Economic evaluation approaches**
  - **Benefit-cost analysis**
  - **Other evaluation approaches**
  - **Project evaluation in the "real world"**
  - **Summary**

CAMBRIDGE SYSTEMATICS

Outline (continued)

- **Lecture 2 – Investment Planning and Programming**
  - **Objectives of programming**
  - **Program structure**
  - **Investment planning/programming framework**
  - **Condition assessment and needs**
  - **Levels of analysis**
  - **Revisit benefit-cost analysis**
  - **Priority setting and program tradeoffs**
  - **Investment planning support tools**

2

CAMBRIDGE SYSTEMATICS

Outline (continued)

- **Lecture 2 (continued)**
  - **Examples**
  - **Case Study**
  - **Conclusions**

3

CAMBRIDGE SYSTEMATICS

Objectives of Project Evaluation

- **Consistent comparison of project costs, benefits, and impacts**
- **Provide basis for deciding on the best alternative for a project and choosing among a set of projects**
- **Transparency – provide understanding of what factors drive project value**

CAMBRIDGE SYSTEMATICS

Basic Questions in Project Evaluation

- **Is the project worthwhile?**
  - **Are the benefits greater than the cost?**
- **Is this the best way to achieve these benefits?**
  - **Can similar benefits be achieved more efficiently by another option?**

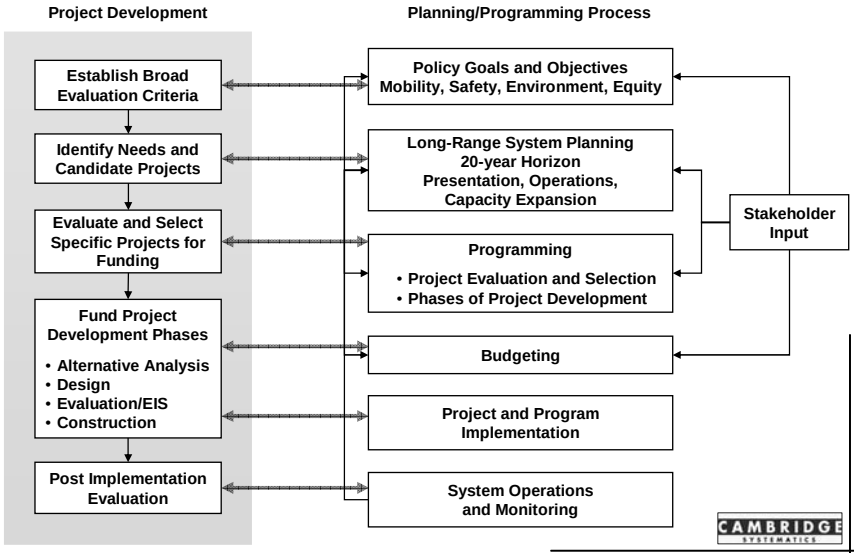
CAMBRIDGE SYSTEMATICS

Basic Concepts

- **Project evaluation not done in a vacuum – part of broader planning, programming, and budgeting process**
- **Types of projects and project tradeoffs can vary widely and require different evaluation methods**
- **Project development/design and evaluation typically are iterative not "one-shot"**
- **For public sector projects there are typically many stakeholders and perspectives involved in evaluating project alternatives for large/complex projects**

6

Project Evaluation
Key Element of Broader Planning Process



7

Typical Steps in Project Development

- Identification of problems and deficiencies
- Identification of options
- Design
- Financial analysis
- Economic analysis
- Environmental impact assessment
- Public hearings

8

CAMBRIDGE SYSTEMATICS

Types of Projects and Evaluation Methods

- **System preservation – most cost effective strategy to maintain pavement condition or fleet availability/reliability**
  - **Technical/engineering factors dominate**
  - **Tools – asset management systems, least life-cycle cost**
- **Improve highway capacity/service in a corridor**
  - **Mobility, cost, and broader environmental/social impacts**
  - **Classic case for benefit-cost analysis as one tool**
- **Improve multimodal service in corridor**
  - **Wide range of evaluation tools and impacts**

CAMBRIDGE SYSTEMATICS

Project Economic Evaluation

CAMBRIDGE SYSTEMATICS

Topics for Discussion

- Economic evaluation versus financial analysis
- Analysis timeframe and discounting
- Discount rate versus inflation
- Typical benefits and costs
- Economic development benefits
- Evaluation criteria and incremental B/C analysis
- Sensitivity analysis
- Limitations

CAMBRIDGE SYSTEMATICS

Economic Evaluation versus Financial Analysis

- Economic evaluation and financial analysis are different
- Both need to be considered in assessing a project's desirability and feasibility
- How a public sector project is financed does not affect whether it is a good investment, but will affect whether and when it can be implemented

CAMBRIDGE SYSTEMATICS

Economic Evaluation

- **Key issue**
  - **Is the project a good investment?**
- **Objective**
  - **Compare economic costs to economic benefits**

CAMBRIDGE SYSTEMATICS

Financial Analysis

- **Key issue**
  - **How will the project be financed (capital and operating)**
- **Objective**
  - **Assess the financial feasibility of the project**
    - **Impact on cash flow and revenue streams (varies depending on financing strategy – current revenue versus bonding)**
    - **Eligibility for various funding programs/sources**
  - **Fiscal impact analysis – long-term impact of project on tax revenues**

CAMBRIDGE SYSTEMATICS

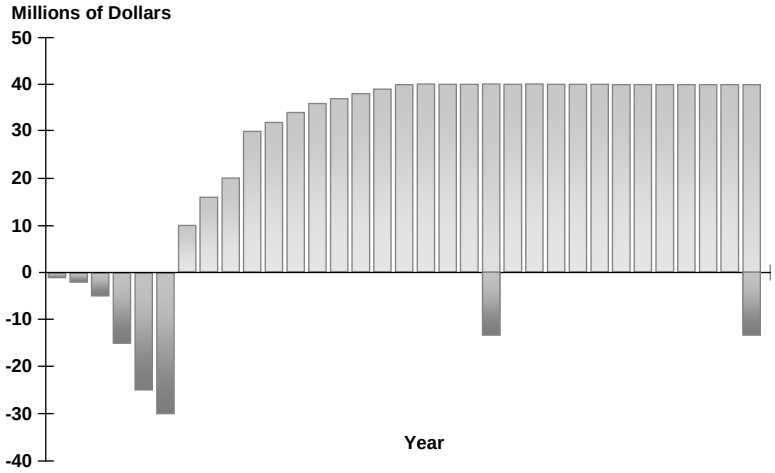
Analysis Timeframe and Discounting

- Need to select an analysis timeframe that captures significant benefits and costs (typically 20-30 years)
- Benefits and costs after 25 years are heavily discounted and can be captured in a residual value
- Need to define the time stream of all benefits and costs of the base case (no-build) and the proposed improvement
- Benefit and cost time streams need to be discounted to the present to provide fair basis for comparison

16

CAMBRIDGE SYSTEMATICS

Time Stream of Benefits and Costs of a Typical Transportation Project



17

CAMBRIDGE SYSTEMATICS

Evaluating Time Stream of Benefits and Costs

- **Key concepts**
  - **Time value of money**
  - **Net present value**
  - **Discount rate**

CAMBRIDGE SYSTEMATICS

Time Value of Money

- **$1 today is worth more than $1 next year because it can be invested. How much more it is worth depends upon the available investment opportunities**
- **Invested at i% per year interest, $1 will be worth $(1+i)^t$ after t years**
- **Similarly, $1 at the end of t years is equivalent to having $\$1/(1+i)^t$ today and investing it at i%**

CAMBRIDGE SYSTEMATICS

Net Present Value

- **Present Value (PV) of future amount (A) at time t:**

$$PV = \frac{A}{(1+i)^t}$$

- **Net Present Value (NPV) is present value of all future costs and benefits**

$$NPV = \sum_t \frac{B(t)-C(t)}{(1+i)^t}$$

- **NPV > 0 Project provides better return than an investment at i% for life of project**
- **NPV < 0 Project not economically justified at i%**

CAMBRIDGE SYSTEMATICS

NPV of $1 Received at Time *t*

	5 yrs	10 yrs	20 yrs	50 yrs	100 yrs
1%	0.95	0.91	0.82	0.61	0.37
5%	0.78	0.61	0.38	0.088	0.0076
10%	0.62	0.038	0.15	0.0085	0.000072
20%	0.40	0.16	0.026	0.00011	0.00000001

Nigel H.M. Wilson

CAMBRIDGE SYSTEMATICS

Discount Rate

- **Discount rate represents the time value of money**
  - **Opportunity cost of using funds for a project versus other competing investment opportunities**
  - **For public sector projects it reflects opportunity costs of taking funds out of the private economy**
- **Selecting a discount rate is key assumption for benefit-cost analysis**
- **Higher the rate the tougher it is for a project to be economically justified since costs typically are incurred in early years (and less heavily discounted) while benefits occur over longer timeframe**

22

CAMBRIDGE SYSTEMATICS

Discount Rate (continued)

- **Low rates favor large projects with long-term benefits. High rates require quicker payback**
- **Greater project risks (costs, benefits, timing, etc.) require higher discount rates**
- **Project owners/sponsors can be very sensitive to selection of a discount rate**
- **Real discount rates (applied to benefits and costs in constant dollars) in 4-10% range typical. U.S. OMB recommends 7% for public projects**

23

CAMBRIDGE SYSTEMATICS

Discount Rate versus Inflation

- Discount rate represents time value of money
- Inflation rate is the decrease in buying power over time
- Easiest way to avoid confusion is to express costs and benefits in constant dollars (inflation doesn't enter analysis in this case) and use a real discount rate
- If benefits and costs expressed in year of expenditure terms then nominal discount rate must be used. Nominal rate is higher than real rate by approximately the annual rate of inflation

24

CAMBRIDGE SYSTEMATICS

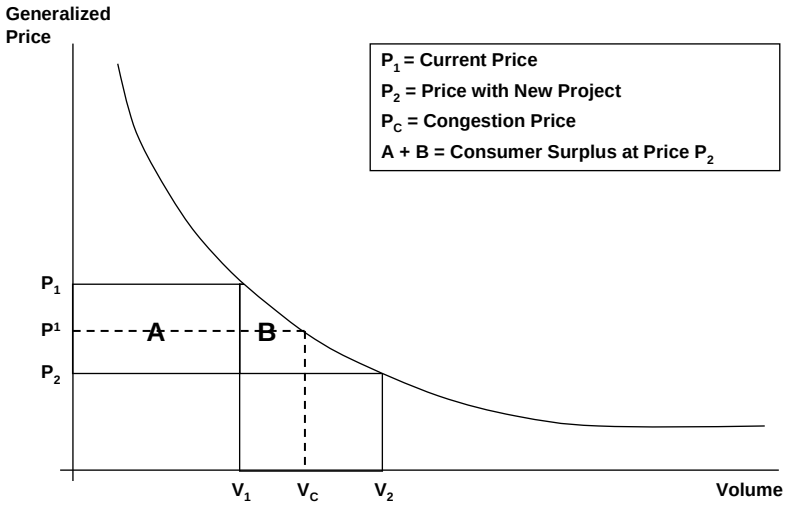
Evaluating Benefits and Costs

- Willingness to pay/consumer surplus
- Impact of pricing
- Typical benefits and costs

25

CAMBRIDGE SYSTEMATICS

Consumer Surplus/Willingness to Pay



26

CAMBRIDGE SYSTEMATICS

Capacity Expansion and Congestion Pricing

- Small/Verhoef discuss impact of pricing on the demand for, and economic benefits of, new capacity
- Congestion price may decrease "induced demand" or shift time of travel etc.
- Congestion price may also impact "operating capacity" or vehicle thru put
- Theoretical impact of pricing assumes efficient pricing on entire network- a condition not likely to be present in most cases

27

CAMBRIDGE SYSTEMATICS

Typical Benefits and Costs

- **Costs**
  - **Initial capital costs**
  - **Periodic rehabilitation/repair**
  - **Ongoing maintenance and operating**
- **Benefits**
  - **Travel time savings**
  - **Vehicle operating cost savings**
  - **Accident cost savings**
  - **Selected externalities**
  - **Residual value (if relevant)**

28

CAMBRIDGE SYSTEMATICS

Benefit Valuation

- **Travel time – value of time varies by**
  - **Trip purpose**
  - **Trip segment (walk, wait, in-vehicle, etc.)**
  - **Auto versus truck**
  - **Socioeconomic group**
  - **Relative time savings (5-minute saving for 20-minute trip versus 1-hour trip)**
- **Accident cost (property damage, personal injury, fatality)**
- **Externalities (air pollution, noise, etc.)**
- **Obvious limitation on what impacts can be included in economic benefit-cost analysis**

29

CAMBRIDGE SYSTEMATICS

Economic Development Benefits

- Analysis methods have been developed to translate user cost savings for trucks/freight movements into broader economic benefits using regional economic models
- Freight user cost savings are translated into a change in the cost of doing business for industries affected
- Business cost savings are input to regional economic model to generate regional impacts on gross regional product, income etc.
- Either direct user benefits OR regional economic benefits can be incorporated into benefit-cost analysis but NOT both. Using both would be double counting

30

CAMBRIDGE SYSTEMATICS

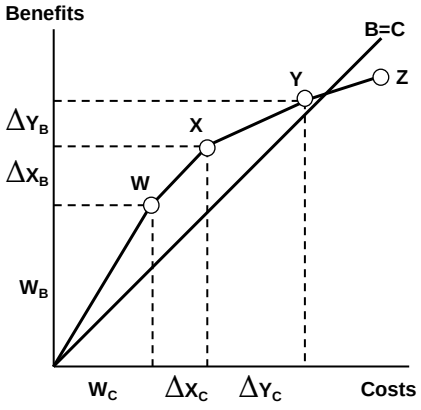
Evaluation Criteria

- Net present value: discounted benefits – discounted costs
- Benefit cost ratio: discounted benefits/discounted costs
- Internal rate of return: discount rate that makes discounted benefits = discounted costs
  (higher the rate the better)
- Payback period: number of years for benefits to equal costs (more relevant for private sector projects)

31

CAMBRIDGE SYSTEMATICS

Incremental Benefit-Cost Analysis



If W,X,Y,Z are independent projects
- **W,X,Y economically justified B/C >1**
- **Z not justified B/C <1**

If W,X,Y,Z are alternatives for the same project
- **W,X,Y justified**
- **X is best**

W_B / W_c >1 B/C ratio

$\Delta X_B / \Delta X_C$ >1 incremental B/C ratio moving from option W to X

$\Delta Y_B / \Delta Y_C$ <1 incremental B/C ratio moving from option X to Y

Sensitivity Analysis

- **It's always good practice to test the sensitivity of benefit-cost results to various assumptions and inputs including**
  - **Cost factors**
  - **Benefit factors or rates (e.g., value of time, etc.)**
  - **Discount rate**
  - **Analysis timeframe including residual value assumptions**
- **If varying assumptions over a reasonable range doesn't make B/C<1 or change the rank order of the alternatives being considered, you can have confidence in the results**

Limitations of Benefit-Cost Analysis

- All impacts of many transportation projects cannot be reduced to dollar terms
- Incidence of benefits and costs on different socioeconomic groups or geographic areas not addressed (it is possible to summarize some benefits and costs by market segment)
- Results sensitive to key assumptions and can be easily manipulated
- Bottom line – benefit-cost analysis is a useful tool but is only one element of a comprehensive evaluation for most projects

CAMBRIDGE SYSTEMATICS

Other Evaluation Approaches

- In "real world" evaluation of large complex transportation projects involves a messy mix of information including
  - Transportation impacts and benefits
  - Costs
  - Full range of impacts
    - Safety
    - Natural environment (air, noise, wetlands, etc.)
    - Social and community impacts
    - Land-use and economic development
    - Equity and incidence of impacts
  - Stakeholder views and degree of consensus
  - Financial feasibility

CAMBRIDGE SYSTEMATICS

Other Evaluation Approaches (continued)

- A full summary of project impacts likely to include quantitative and qualitative information. Some of the quantitative information can be included in a benefit-cost analysis
- Challenge – how to display and communicate key project impacts to decision-makers and other stakeholders
- Visualization and simulation tools providing new capabilities to describe and communicate project impacts

CAMBRIDGE SYSTEMATICS

Legal and Regulatory Environment for Project Evaluation

- Many project evaluation requirements are defined in statute and regulation in U.S. These include
  - Environmental impact statement (NEPA and state law)
  - Clean air
  - Historic preservation
  - Endangered species
  - Parkland protection (Section 4(f))
  - Access for disabled
  - Civil rights (environmental justice related to distribution of impacts)

CAMBRIDGE SYSTEMATICS

Legal/Regulatory (continued)

- Notably, in most cases, benefit-cost analysis is not required in U.S. with some exceptions (FTA New Starts). Next Federal reauthorization may address this issue
- Use of benefit-cost analysis much more common internationally and in developing country environments where projects funded by international aid/funding organizations
- Post project evaluation (to confirm whether predicted impacts actually occurred) seldom done in U.S. though not uncommon in some countries (Japan, Australia)

CAMBRIDGE SYSTEMATICS

Conclusions

- Rigorous project evaluation is a key component of the decision-making process
- Objective is to provide comprehensive summary of all key project impacts
- Many tools and approaches available to support project evaluation including benefit-cost analysis
- Challenge is summarizing key differences among project alternatives in an effective manner
- While decision informed by good technical information, choices are fundamentally policy and political in nature

CAMBRIDGE SYSTEMATICS

1.201J / 11.545J / ESD.210J Transportation Systems Analysis: Demand and Economics
Fall 2008