Building Success and Avoiding Surprises:

The Use of Risk Analysis and Decision Making

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Time for Public Confession!

• When assessing project’s worthiness, the effects of various economic risks (economic downturn, land use changes, etc.) are rarely assessed.

• Over 40% (1) of infrastructure projects exceed their budget and/or their schedule, mainly due to unexpected events (risks).

• Over 80% (2) of toll roads miss their traffic and revenue forecast because they don’t account for uncertainties around key assumptions.

(1) Flyvbjerg 2003
(2) Standard and Poor 2002 and 2003 studies
Whether for Economics, Finance, or Cost, An estimate is like a strike zone

A strike zone is not a single point.
Risk Analysis As a Tool To Account for Uncertainty and Build Credibility

Risk Analysis Process (RAP)

A consensus-based process that promotes transparency, accounts for uncertainty, and recognizes interrelationships between variables and their associated probability distributions.

- **Step 1**: Define structure and logic diagrams to illustrate model components;
- **Step 2**: Assign central estimates and ranges (probability distributions) to all key variables;
- **Step 3**: Engage experts and other stakeholders to assess the model and assumptions; and
- **Step 4**: Conduct the simulations to produce probability distributions for CBA indicators.
Risk Analysis Process vs. Traditional Feasibility Studies

Traditional Studies Provide Single-Point Estimates

Risk Analysis Provides all Potential Outcomes and their Probability

"I would rather be approximately right than precisely wrong"

Warren Buffet
Why Risk Management?

Risk Management provides significant value by:

• Encouraging pro-activity and early planning
• Developing mitigation strategies for all anticipated threats
• Building confidence and credibility in project’s plans and estimates
• Ensuring transparency and integrity throughout the life-cycle of the project
Risk Analysis Application Throughout the Economic and Financial Planning Process

Economic Feasibility: Need, Worthiness, and Cost

Financial Feasibility and Program Capacity
“Never mind these cost-benefit analyses. All we want to know is what’s the cost... and what’s the benefit.”
Estimating the Project Worthiness

FHWA and NCHRP research reveals that, when well planned, highway investment yields social and economic benefits for communities. These gains include,

- Reduced congestion and improved reliability;
- Lower vehicle operating costs;
- Improved safety in the region;
- Lower air emission due smoother speed and lower congestion;
- Greater demand for commercial floor-space and correspondingly higher commercial property values; and
- More highly valued residential property due to the locational and environmental benefits.
Uncertainty Surrounds Various Aspects of Project’s Costs and Benefits /Revenues.

Benefits

- Private Shareholders
  - Toll Revenues
  - Development Fees
  - Public Subsidy (when applicable)

- All Taxpayers
  - Congestion Relief
  - Environmental Cost Savings
  - Highway Maintenance Cost Savings
  - Vehicle Operating Cost Savings
  - Safety Savings
  - Economic Development

Costs under Financing Options

- Operations and Maintenance Costs ($)
- Land Acquisition Costs ($)
- Capital Costs/Cost of Capital ($)
- Capacity Related Costs ($)

Discounting (%)

Total Benefits and Risks ($)

NPV Optimal Financing Structure

Total Costs and Risks ($)
Risk Factors to Project Worthiness

- Demographics Growth;
- Land Use Development and future development trends;
- Employment and Income Growth Risks;
- Value of Time;
- Competing Roadways Effects;
- Lane Closure for Rehabilitation Effects; and
- Operating and Maintenance Costs

... good managers manage risks, poor managers manage problems
Risk Analysis Comprehensively Accounts for Uncertainties Surrounding Key Assumptions

\[ F = f (A, B, C, D, \ldots) \]
Risk-Based Projections

- Number of Trucks (Thousands)
- Year

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Trucks</th>
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<tbody>
<tr>
<td>1980</td>
<td>450</td>
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<tr>
<td>1990</td>
<td>400</td>
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<td>2000</td>
<td>350</td>
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<td>2010</td>
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<td>2020</td>
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<td>2030</td>
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<td>2060</td>
<td>50</td>
</tr>
<tr>
<td>2070</td>
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- OM Trucks Data
- Lower Boundary Forecast
- Median Forecast
- Upper Boundary Forecast
## Risk-Based Economic Assessment

### Simulation Results

Millions of Dollars of 2006, Unless Stated Otherwise

5% Real Discount Rate

30 Year Horizon, 2006-2035

<table>
<thead>
<tr>
<th>Categories of Benefits</th>
<th>Mean</th>
<th>Lower 10%</th>
<th>Upper 10%</th>
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<tbody>
<tr>
<td><strong>Congestion Management</strong></td>
<td></td>
<td></td>
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<tr>
<td>Travel Time Savings</td>
<td>$458.7</td>
<td>$258.5</td>
<td>$1,299.8</td>
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<tr>
<td>Accident Cost Savings</td>
<td>$369.7</td>
<td>$199.9</td>
<td>$539.3</td>
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<tr>
<td>Vehicle Operating Cost Savings</td>
<td>$185.9</td>
<td>$142.2</td>
<td>$259.9</td>
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<tr>
<td>Emission Cost Savings</td>
<td>$2.0</td>
<td>$1.2</td>
<td>$6.3</td>
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<tr>
<td><strong>Total Congestion Management</strong></td>
<td>$1,016.3</td>
<td>$601.8</td>
<td>$2,105.3</td>
</tr>
<tr>
<td><strong>Grand Total Benefits</strong></td>
<td>$1,016.3</td>
<td>$601.8</td>
<td>$2,105.3</td>
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<tr>
<td><strong>Project Costs</strong></td>
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<tr>
<td>Capital Costs</td>
<td>$323.7</td>
<td>$293.5</td>
<td>$353.3</td>
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<tr>
<td>Incremental O&amp;M Costs</td>
<td>$156.5</td>
<td>$0.0</td>
<td>$172.4</td>
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<td><strong>Total Project Costs</strong></td>
<td>$480.2</td>
<td>$293.5</td>
<td>$525.6</td>
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<td><strong>Net Present Value</strong></td>
<td>$536.1</td>
<td>$308.3</td>
<td>$1,579.7</td>
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<tr>
<td>Modified Internal Rate of Return, %</td>
<td>6.3%</td>
<td>4.8%</td>
<td>9.1%</td>
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<td>Payback Period, Years</td>
<td>15.0</td>
<td>11.0</td>
<td>20.0</td>
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<td>First Year Return, %</td>
<td>10.5%</td>
<td>7.7%</td>
<td>14.4%</td>
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</table>

[Image: Reduce Speed Drama Construction Ahead]
Risk Analysis to Assess Toll Roads Feasibility
Traditional T&R Forecasts Have Been Found to Systematically Overestimate Toll Revenue

- **J.P. Morgan (1997):** 14 of 15 toll road traffic volumes were over estimated by 25+%
- **Standard & Poor’s (2002):** 28 of 32 toll road traffic volumes were over estimated by 30+%
- **Standard & Poor’s (2003):** 68 toll road traffic volumes were over estimated by 26+. Even toll roads with history over estimated traffic by nearly 20%:


*Most T&R studies have led to poor forecasting performance and weak credit rating*
Traditional T&R Forecasts Have Lost Credibility
Enhancements to Existing TDM Improve Forecast By Accounting for Uncertainties in Assumptions

Augmented model simulates all possible scenarios leading to more reliable forecasts
Risk-Based Market Assessment

Net Present Value (Revenue minus O&M) for Various Discount Rates

$528,848,635
$952,922,686
$1,476,021,077
$449,521,340
$809,984,283
$1,254,679,157
$314,664,938
$566,988,998
$878,232,541
$439,116,270

0.0%
10.0%
20.0%
30.0%
40.0%
50.0%
60.0%
70.0%
80.0%
90.0%
100.0%

NPV (2007 Dollars)

Probability of Not Exceeding NPV - 4% Discount Rate
NPV - 6% Discount Rate
NPV - 8% Discount Rate
NPV - 10% Discount Rate
Probabilistic Coverage Projections Are Communicated with Rigor and Clarity

<table>
<thead>
<tr>
<th>Fiscal years</th>
<th>Probability of exceeding the DSCR</th>
<th>Probability of Exceeding</th>
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<tbody>
<tr>
<td></td>
<td>99%</td>
<td>95%</td>
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<tr>
<td>2004</td>
<td>2.51</td>
<td>2.53</td>
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<tr>
<td>2005</td>
<td>1.71</td>
<td>1.74</td>
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<tr>
<td>2006</td>
<td>1.68</td>
<td>1.70</td>
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<tr>
<td>2007</td>
<td>1.63</td>
<td>1.65</td>
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<tr>
<td>2008</td>
<td>1.59</td>
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<td>2009</td>
<td>1.48</td>
<td>1.51</td>
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<td>2016</td>
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<td>2024</td>
<td>0.88</td>
<td>0.92</td>
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</table>

There is a 75% probability that DSCR in fiscal year 2008 will be at least 1.67.
## Risk Analysis Facilitate Partnerships: Risk-Reward Sharing Strategy

<table>
<thead>
<tr>
<th></th>
<th>Public Partner</th>
<th>Private Partner</th>
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<tbody>
<tr>
<td></td>
<td>Expenditure</td>
<td>ROI</td>
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<tr>
<td><strong>Option 1</strong></td>
<td>$700</td>
<td>5%</td>
</tr>
<tr>
<td><strong>Option 2</strong></td>
<td>$500</td>
<td>12%</td>
</tr>
<tr>
<td><strong>Option 3</strong></td>
<td>$350</td>
<td>16%</td>
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</table>
Risk Analysis for Cost and Schedule Estimates

Examples of Project Cost Growth, US(*)

Boston
Central Artery / Tunnel

London Jubilee Line Metro
Life Cycle Project Cost

- Project Plan & Concept
- 30% Design
- 100% Design
- Construction Completion

- Unrecognized Cost
- Known but Not Quantified
- Known and Quantifiable (can include small uncertainty)

Total Cost at Construction Completion

Estimate at any point in time

Total = Conservative Deterministic Estimate (with Allowance)
Cost Estimation Process
Traditional vs. Risk-Based Approach

Project Deterministic Estimate

Fixed Contingency %

Geotech 20%
Materials 40%
Environmental Requirements 30%
Design 5%

Project Base Cost
Examples of Cost Risk Factors

- Construction schedule risks;
- Third-Part Agreements;
- Environmental Risks;
- Market Conditions Risks,
- Procurement Risks;
- Project Management Risks,
- Right of Way Risks;
- Performance Standards;
and
- Financial Risks.
Risk Assessment Process

- **Risk Factor**: Delay of NEPA Process
- **Probability of Occurrence**: 33%
- **Potential Effects**:
  - Cost Increase: $2M
  - Schedule Delay: 12 months

**Overall Effect of the Project Cost**
Overview Risk Assessment Approach

Budget Risk Assessment
- Preliminary Engineering & Environmental
- Final Design
- Construction Management
- Right of Way
- Subgrade Construction
- Track Construction
- Separate Access Road
- Bridges / Structures
- Signals / Communications / Dispatch
- Buildings / Shops
- Environmental

Event Risk
- Archeology
- Construction
- Environmental
- Military
- Engineering
- Executive
- Funding
- Geotechnical
- Hydrology
- Materials
- Maintenance
- Operations
- Permits
- Right of Way
- Schedule
- Project Viability

Quantities

Project Schedule

Project Cost by Segment and Overall

Prices
Support the Decision Process - Project Cost

RISK ANALYSIS OF TOTAL PROJECT COSTS

<table>
<thead>
<tr>
<th>Probability of Not Exceeding</th>
<th>Total Project Cost (Millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>$281.5</td>
</tr>
<tr>
<td>90%</td>
<td>$281.5</td>
</tr>
<tr>
<td>80%</td>
<td>$275.0</td>
</tr>
<tr>
<td>70%</td>
<td>$260.5</td>
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<td>60%</td>
<td>$247.7</td>
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<td>$217.5</td>
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<tr>
<td>20%</td>
<td>$209.3</td>
</tr>
<tr>
<td>10%</td>
<td>$200.5</td>
</tr>
<tr>
<td>0%</td>
<td>$199.6</td>
</tr>
</tbody>
</table>

Baseline:
- Non-Escalated: $150.3
- Escalated: $172.8

Bid Price:
- 02/07: $219 M

HDR
Support the Decision Process
- Project Schedule

Actual schedule float: 0 months
Adequate schedule float: 28 months (90% probability of under run)
Support the Decision Process
Prioritization of Risks

Tornado Chart: Correlation with Total Project Cost

- Unexpected construction staging issues (during DESIGN/PS&E)
- Mitigation utilizing WDFW parcel
- Winter roadway work
- Rest area improvements design coordination challenges
- Reduce amount of compost
- Piezometer readings effecting pond designs
- Unknown cultural resources discovered during construction
- Moving temporary barrier
- Reduction in storm water pond size
- Design deviations unapproved
- Coordination challenges
- Fish habitat and passage issues
- Unsuitable foundation excavation & fill costs
- Uncertainty in the environmental permitting process
- NEPA DCE vs. EA
Support the Decision Process
One Page Summary / Briefing

**October 2004**

**Executive Summary - Risk Report**

Metropolitan Transportation Authority

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**South Ferry Project**

**General**

Summary: Based on a full evaluation of UNCERTAIN FC parameters, the DCF dollar value of the project is shown to be in a favorable range, making a 50% probability of being favorable to the project. The key finding is that the project is not as financially sound as initially thought. The decision to proceed with the project should be made with caution.

**Cost**

- Top Five Risks and Mitigation Strategies:
  - [Diagram or table listing top risks and mitigation strategies]

**Schedule**

- Top Five Risks and Mitigation Strategies:
  - [Diagram or table listing top risks and mitigation strategies]

**Grant**

- Top Five Risks and Mitigation Strategies:
  - [Diagram or table listing top risks and mitigation strategies]

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**I-5 Grand Mound to Maytown Widening Project**

**Project Description**

- **Project Benefits:**
  - Reduces traffic and LOS 11.1
  - Enhances safety and reduces fatal and injury crashes
  - Improves roadway safety and provides more lanes
  - Improves traffic flow and reduces delays

**Project Costs:**

- **Cost Analysis:**
  - 90% new construction: $100 million
  - 10% maintenance: $10 million

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**Financial Analysis (Key Assumptions):**

- **Assumptions:**
  - 3.0% interest rate
  - 3.0% inflation rate
  - 3.0% construction cost increase

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Page 1 of 3
Risk Management

• Risk Assessment’s aim is to assess potential impact of various scope, event, and budget risks on the project’s cost and schedule.

• Risk Management’s aim is to identify opportunities and mitigation strategies to reduce both the likelihood of an event occurrence and the potential effect if it occurs.
Risk Analysis Helps the Involvement of Experts and Stakeholders

- A risk analysis workshop is held to review and revise the models and forecasting assumptions with:
  - Concession analysts
  - T&R forecasters
  - Local experts – land use socio-economics, transportation, etc.
  - Industry representatives – rating agencies
“New Logo” for Effective Project Management!

Denial is NOT an Option