Forecasting Revenue and Ridership for High Speed Rail

High Speed Rail – Perspectives and Prospects
Fifth Annual William O. Lipinski Symposium on Transportation
November 14, 2011

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OUTLINE

- Prediction is Difficult
- Uncertainty is Part of All Prediction
- Importance of Forecasting Ridership
- Why is Forecasting HSR Ridership so Challenging
  - Data Challenges
  - Methodology Challenges
  - Uncertainty Challenges
- Judgment and Peer Review Panels
"Prediction is very difficult, especially if it's about the future."

Nils Bohr, Nobel laureate in Physics

Difficult to Predict with Much Precision:

- Which Horse will win the Race,
- Which stocks (if any) will do well this year,
- What low emissions technology will be first to market, or
- How Many Cars/Trucks will use Toll Roads, Bridges and Tunnels
Uncertainty

While the level of understanding and the amount of data regarding travel behavior has never been better, significant uncertainty remains.

We shouldn’t fear uncertainty regarding future travel forecasts; we should evaluate and plan for it.
High Risk (Uncertainty) of HSR Investments

- Capital Investment is both Long- term and High Cost
- Limited Flexibility
  - No geographic flexibility of investment (Rails and Stations Cannot be Moved to Stronger Market)
  - Limited Technological Flexibility
- Relatively Fixed Operating Costs
- Many Development Attributes are Uncertain over Time
- Many Cost Elements are Uncertain over Time
- Private and Public Sectors have different Benefits and Costs
Travel Growth Trends are Uncertain

- **VMT in Millions**
  - Graph showing VMT in millions from 1969 to 2008.
  - Increase in VMT from 500,000 to 2,500,000.

- **VMT per Person**
  - Graph showing VMT per person from 1969 to 2008.
  - Increase in VMT per person from 500 to 9,000.

- **Travel Time per Capita**
  - Graph showing travel time per capita from 1977 to 2008.
  - Decrease in travel time from 450 hours to 250 hours.

- **Disposable per Capita Income**
  - Graph showing disposable income from 1950 to 2010.
  - Increase in disposable income from $0 to $35,000.
WHAT WILL THE COMPETITION Do?

Roadway LOS

Communications Substitution

Airline Substitution

InterCity Bus
Low-Fare, Curbside Bus Operators Picking Up Amtrak Market Share
Hartford Courant, August 1, 2011
What will be the comparative security screening/boarding times?
WHAT FOOD SERVICES, LUGGAGE, REWARD PROGRAMS WILL BE ADOPTED IN FUTURE

Amtrak National Dining Car Menu

LUNCH
MAIN COURSES
All lunch entrees include coffee, tea or milk.

Fresh Made Vegetarian Entrée Salad ........... $8.00
Your server will describe today's salad bar selection served with a dressing selection and a warm roll. (Available with a $0.50 gratuity surcharge for an additional $3.00)

Grilled Veggie Burger .................................. $9.50
A full flavored veggie burger served on a bakery bun with lettuce, tomato, red onions, pickle, potato chips and optional chili cheese.

Angus Steak Burger ................................... $9.50
Grilled Angus beef chuck burger served on a bakery bun with lettuce, tomato, red onions, pickles, potato chips and optional chili cheese. (Available with two smoked bacon strips for an additional $2.00)

Today's Fresh Made Sandwich ............... $8.50
Ask your server to describe today's specialty offering.

Chef's Marketplace Special ............... $10.75
Today's selection will be the special of the day and offered along with an appropriate side, small garden salad, dressing selection and warm roll.

DINNER
MAIN COURSES
All dinner entrees include a small salad with dressing, warm roll and coffee, tea or milk.

Vegetarian Pasta ................................... $14.00
Today's meatless selection will be described by your server.

Herb Roasted Half Chicken ....................... $24.75
Thigh meat, chicken, served with rice pilaf and a vegetable medley. (Carrots and broccoli are served as a garnish.)

Chef's Evening Marketplace Special ........... $18.50
Your server will describe tonight's special offering.

Seafood Catch ........................................ $19.75
Ceviche-style seafood salad with your choice of main entree served with rice pilaf, vegetable medley and a special sauce designed to complement the selection. (Main course will be determined randomly with your choice of main entree.)

Grouper's Cut Choice Steak ....................... $24.75
The specific cut of skinless, boneless fish served with rice pilaf, vegetable medley and a special sauce designed to complement the selection. (Main course will be determined randomly with your choice of main entree.)

Our Menu
Chili Cheese Hamburger
Chicken and Wraps
Organic Salads
Our Menu
My 99 Cents Everyday Value Menu

Chili Cheese Hamburger
Cheesy Cheddar Burger
Crispy Chicken Sandwich
Double Blackened Chicken
Cheesy Chicken Sandwich
Free Spicy Chicken Nuggets
Value Fries
Shake
Value Drink

About Nutrition

U.S. AIRWAYS
DIVIDEND MILES

CitiBusiness
4122 9001 2345 6789
L. Walker
Company Name

Citi
VISA
LOCAL CONNECTIVITY
What local transit will exist when? What will it cost to use and to
WHAT EVENTS WILL IMPACT PASSENGERS’ PERCEPTIONS OF RELIABILITY, SAFETY AND SECURITY

LATEST UPDATE: 03/02/2010

TRAIN WORKERS STAGE NATIONWIDE STRIKES AGAINST DOWNSIZING PLANS

WORKERS AT FRANCE’S NATIONAL RAILWAY COMPANY SNCF BEGAN A STRIKE LATE TUESDAY TO PROTEST AGAINST NATIONWIDE DOWNSIZING PLANS. TWO THIRDS OF HIGH-SPEED TRAINS AND 50% OF REGIONAL TRAINS ARE EXPECTED TO RUN.

BY NEWS WIRES (TEXT)
Intercity passenger rail investment would help meet important national energy and environmental goals by shifting travel to trains, which consume approximately 17 percent less energy per passenger mile than air carriers and 21 percent less energy per passenger mile than automobiles.

Recommendations, National Surface Transportation Policy and Revenue Study Commission: Transportation for Tomorrow, December 2007

“Boeing estimates that aircraft entering service today are 70% more fuel efficient than the jets of the 1960s...” “... the Dreamliner will produce 20% fewer emissions and consume 20% less fuel than other comparably sized aircraft.”

METAEFFICIENT, 2009
WHAT WILL BE THE INDUCED DEVELOPMENT AND DEMAND?

Regional Land Use Impact
The effect of such projects in other countries has been to strengthen the competitive advantage of an already dominant city.

The Economist, September 3rd, 2011

Local Land Use Impact
High speed lines are unlikely to have local accessibility benefits separate from connecting local transit lines because there is little advantage for most people or businesses to locate near a line used infrequently (unlike public transit).

David Levinson, Economic Development Impacts of High-Speed Rail, 2010
Ridership is one uncertain element in forecasting economic viability.

Ridership —> Fares —> Revenue

Service Levels —> Operating Cost

Capital Cost —> Project’s Economic Viability

Operating Cost = Annual Operating Profit or Loss

- Labor Levels
- Labor Cost Culture
- Amtrak?
- Regional Airline?
MANY ELEMENTS ARE UNCERTAIN

Ridership → Fares → Revenue

Service Levels → Operating Cost

- Labor Levels
- Labor Cost Culture
  ➢ Amtrak?
  ➢ Regional Airline?

= Annual Operating Profit or Loss

Capital Cost → Project’s Economic Viability
ENVIRONMENT CAN BE CHALLENGING TO OBJECTIVE RIDERSHIP FORECASTING

- Professional community eager to support projects that might get funded
- Thin ranks of experts
- Non-experts Claim Understanding without Basis
- Public Advocates May be Excessively Optimistic
- No timely feedback – design year too far away to provide feedback to forecasters
- Uncertainty Risks may be Dismissed by Some Who Believe they can Change the Future
A Growing Culture of Skepticism and Cynicism

Truth and Lies About Megaprojects
Inaugural speech
Bent Flyvbjerg
September 26, 2007

Mijnheer de Rector Magnificus,
Leden van het College van Be
Collegae hoogleraren en leden
Zeer gewaardeerde toehoorders,
Dames en heren,

This paper reviews the traffic forecasting performance of toll roads, explores the potential sources of forecasting errors through a literature review and suggest some possible measures that may be used to reduce traffic forecasting errors.

In general, the forecasting performance for toll roads in the world has been found to be poorer than for toll-free roads. There is an asymmetrical pattern of forecasting errors, that is, consistent overestimation. Australia is no exception. Anecdotal evidence suggests that the forecasting performance for Australian toll roads may have been even worse than the world average.

Forecasting errors can be caused by many factors including inadequate models; data limitations, uncertainties in socio-economic and land use forecasts, ramp-up risks, and optimism bias and/or strategic misrepresentation.
Why is it so Important to Forecast High Speed Rail Utilization/Ridership?
Importance of R&R Forecasting
Public and Private Evaluation

- High Speed Rail Evaluation based on Public and Private Investment
- Public and Private Benefits Determined by Ridership and Revenue
- Public and Private Costs are based on Routes, Alignment, Design, Ridership and Operating Decisions
- Revenue Benefit is based on Ridership and Fare Structure
Importance of R&R Forecasting
Public and Private Evaluation

- P&P Investment based on Estimated Capital Investment and Source Allocation
- P&P Benefits based on Revenue and Allocation
- Public Benefits also based on Ridership and Development Impacts
- P&P Costs based on Operating Decisions and Source Allocation
- Investment, Revenue and Cost Risks are shared between P&P Sectors based on Allocation Agreement
Importance of R&R Forecasting
Private Perspective

- **Return on Investment**
  - Capital Investment
  - Annual Costs
    - Operations
    - Maintenance
  - Annual Revenue
    - Ridership
    - Net Fares
  - Return on Investment

- **Risk Analysis**
  - Distribution of forecasts
  - Measures of uncertainty
Importance of R&R Forecasting
Public Perspective Benefits

- Capital Investment
- Annual Costs
  - Operations
  - Maintenance
- Annual Revenue
  - Ridership
  - Net Fares
- External Benefits
  - Avoid or reduce investments in roads and airports
  - Reduce congestion and increase safety on roads
  - Encourage economic development
- Benefit–Cost Analysis
Why is Forecasting a Challenge?

What Gaps must be filled in Data?
Challenge of Forecasting Data

- Travel data
  - Survey design
  - Sample size and design
- Service Data and Prices by Travel Model
  - Travel time by component
  - Schedules for carrier modes
  - Reliability
  - Security and safety
  - Perception
  - Fares
- Contextual data
  - Development pattern
  - Transit to feed HSR stations (local connectivity)
Regional and Intercity Travel Data:
  » Census Transportation Planning Package
  » American Community Survey
  » Statewide Travel Survey (NHTS and NHTS add-on)
  » American Travel Survey (1995)

Data by Mode
  » Air Passengers: U.S. DOT, FAA 10% ticket sample
  » Rail Passengers: Rail providers and MPOs
  » Highway Volumes: State DOTs and MPOs

Survey Data: Revealed and stated preference surveys
Data Inputs and Model Tasks

- Household Survey
- Intercept Surveys
- Stated Preference
- Highway Networks
- Rail & Air Networks
- Traffic Counts
- Rail and Air Ridership

Flow Diagram:
- Trip Generation
- Distribution / Destination
- Mode Choice
- Network Assignment
### Stated Preference Survey

#### TRAVEL BY CAR

- You travel whenever you would like.
- The typical travel time in the car is **6 hrs 30 min** (not including stops for rest, food, etc.)
- 50% chance of arriving within **15 min.** of the typical time
- The roundtrip fuel cost is **$70**

#### TRAVEL BY AIR

- Travel to and from the airports is the same as you described earlier in the survey (questions 15 - 19)
- You should arrive at the airport at least **1 hour** before your flight.
- There is a flight **every 1 hour**
- The scheduled travel time in the plane is **1 hr 20 min**
- 80% of flights arrive within **15 min.** of schedule
- The roundtrip fare is **$320**

#### TRAVEL BY HIGH SPEED RAIL

- Travel to and from the stations is the same as you described earlier in the survey (questions 20 - 27)
- You should arrive at the station at least **10 min.** before your train.
- There is a train **every 1 hour**
- The scheduled travel time in the train is **2 hrs 40 min**
- 85% of trains arrive within **5 min.** of schedule
- The roundtrip fare is **$140**
Methodological Challenges?
Challenge of Forecasting Methodology

- Models
- Decisions on range of choices to consider
- Structure of models – different degrees of competition
- Form of utility/value function
- Estimation of model parameters
Questions:

- What is the market size?
- Where are trips attracted?
- What are key travel markets?
- How many trips by HSR?
- Where are rail trips distributed?
- Level of highway congestion?

Model System Components:

- Trip Generation
- Trip Distribution
- Market Segmentation
- Mode Choice
- O-D Flows
- Highway Assignment
## Model Estimation

### If you want to evaluate changes in:
- Running times
- Station location
- Frequency of service
- One ride versus multiple transfers
- Fare changes
- Gasoline prices
- Terminal processing time
- On-board and terminal amenities

### You need to know the relative importance of:
- In-vehicle travel time
- Walk time / Drive access time
- Schedule convenience
- Number of transfers
- Rail, air, and bus fares
- Travel costs by auto
- Wait time
- Lounge, wi-fi access, seating, etc.
Theory: A Disaggregate Approach
Structure of Models
Competitiveness

No Trips

Two-Plus Trips

Zone 1

Zone 2

Zone N-1

Zone N

Car

Rail

HSR

Air

Drive and Park

Drop Off

Rental Car

Taxi

Transit

Walk

Unpark and Drive

Picked Up

Rental Car

Taxi

Transit

Walk
Model Estimation
Relative Importance of Related Variables

Access  |  Wait  |  Travel  |  Egress
---------|--------|----------|--------
1:00     |        |          |        
2:00     |        |          |        
3:00     |        |          |        
4:00     |        |          |        

Actual travel time

Perceived travel time
What is the Nature of Uncertainty?

How can we Address it?
Challenge of Forecasting Uncertainty

- Models are probabilistic
- Future context is uncertain
- Forecasts of future year inputs
- Acceptance of high speed rail
- Future operating and pricing conditions are unknown
- Real-world competitive responses
Uncertainty
Choice Context and Models

- No comparable high speed rail service in the US
  - Analysis of observed behavior
  - Forecasts for a new mode
  - Stated preference surveys

- Acceptance of high speed rail
  - By market segment
  - High speed rail constant

- Properties of the model
  - Sensitivity to level of service and costs
  - Differences by market segment and geography
Replicating 2010 Conditions

2010 Highway Network
2010 Population and Employment
2010 Land Use
2010 Air/Rail Network
2010 Service and Pricing

Model System

Observed Ridership
Ridership & Traffic Estimates
Traffic Counts
Uncertainty for Future
Total Demand and Market Share

- **Total travel – Model inputs**
  - Population
  - Employment
  - Traveler incomes
  - Are growth forecasts reasonable?

- **Competitive landscape – Model inputs**
  - Gasoline costs
  - Highway level of service
  - Competitive response by air carriers
    - Air fares
    - Frequency of air service
    - Competing vs. complementary service
Forecasting in 2035

2035 Highway Network
2035 Population and Employment
2035 Land Use
2035 Air/Rail Network
2035 Service and Pricing
High Speed Rail

Model System

Ridership Forecasts
Traffic Forecasts
Impact of Input Assumptions
Urban Rail Forecasts

Ridership

<table>
<thead>
<tr>
<th>Feature</th>
<th>Ridership</th>
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<tbody>
<tr>
<td>Peak/Off-peak 30/60 min</td>
<td>5,000</td>
</tr>
<tr>
<td>Headway 5/10 min</td>
<td>15,000</td>
</tr>
<tr>
<td>Rail Fare 75 cents</td>
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</tr>
<tr>
<td>Downtown Parking</td>
<td>20,000</td>
</tr>
<tr>
<td>Station Land Use</td>
<td>20,000</td>
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Addressing Uncertainty

- Transparent assumptions
- Range of outcomes
  - Sensitivity runs to evaluate impact of inputs
  - “What if” scenarios affecting total travel and competition
- Replication of a known “higher speed rail” service
- Estimates bounded by international experience
- Downside risk and upside potential
Judgment & Peer Review Panels

- Judgment: Almost All Elements of Data Collection, Model Estimation And Forecasting are Subject to Judgment.

- Minimize Errors in Judgment

- Peer Review Panels

  - Essential Attributes
    - Highly Qualified Experts in Relevant Areas
    - Independent and with No Conflicts of Interests
    - Diverse Perspectives

  - Approach
    - Early Involvement in Project
    - Full Access to All Relevant Reports, Analyses and Data
    - Report Directly to Highest Levels of HSR Authority

- Common Objective: Produce High Quality Forecasts That Take Account of Uncertainty
Questions?
Passenger surveys
  » Revealed and stated-preference
  » Components
    • Air intercept (1,234)
    • Rail intercept (431)
    • Auto household (1,508)
  » Completed
    • 3,173 complete surveys
    • 2,678 geocoded surveys
» Four SP exercises per

Urban Area Household Travel Surveys from MPOs
  » SCAG (343)
  » MTC (723)
  » SACOG (318)
  » 1,384 revealed-preference surveys

Caltrans Household Travel Survey
  » 2,820 revealed-preference surveys
Travel Time Components – Door to Door

- **Auto**: 530 min
- **High-Speed Rail (HSR)**: 231 min
- **Air**: 194 min

Legend:
- Access Origin to Station
- Terminal Curb to Waiting Area
- Wait to Board Vehicle
- Line-Haul In-Vehicle
- Terminal Seat to Curb
- Egress Station to Destination

**Travel Time in Minutes (Year 2030)**

“May 2009 Operating Plan” scenario
Model Estimation
- Understanding of traveler behavior
- Analysis of policy-sensitive variables
- Development of statistical relationships ("models")

Model Validation
- Base-year socioeconomics
- Base-year levels of service
- Base-year validation data as targets
- Adjustments to meet ridership and traffic targets

Forecasting: Application for the Future-year
## Values of Time

### Derived Values-of-Time (2005 $ Per hour)

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<tr>
<th></th>
<th>Main Mode</th>
<th>Access / Egress</th>
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<tbody>
<tr>
<td><strong>Long Trips</strong></td>
<td></td>
<td></td>
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<tr>
<td>Business/Commute</td>
<td>$64</td>
<td>$48</td>
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<tr>
<td>Recreation/Other</td>
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<td>$15</td>
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