Economic Development Effects of Highway Investment

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Outline

- Introduction
- Motivation
- Research Objectives
- Study Framework
- Data
- Methodology
- Analysis Results
- Conclusions
- Future Research
Introduction

- **Economic Analysis:**
  - Benefits and costs to society
  - Impacts on:
    - Transportation system users (*travel time, safety, VOC*)
    - Environment (*noise, emissions, energy*)
    - Economic development
Introduction (cont’d)

- Economic Development:
  - Impacts on the level of econ. activity:
    - Jobs
    - Disposable income
    - Business sales/output
    - Investment
    - Econ. productivity
Econ. Dev. Effects

- Direct
- Indirect
- Induced
- Multiplier Effects: indirect & induced effects
- Static (no time dimension)
- Dynamic (long-term)
Transport Project/Program

Change in Costs, Markets for Directly-Affected Businesses

Indirect effects (supplier businesses)

Multiplier effects on business

Direct Effect: Change in Business Activity (output)

Purchase Supplies (capital inputs)

Induced effects (consumer businesses)

Pay Workers (wages)

Sum of direct, indirect & induced effects

Retain Earnings (profits, reinvest.)

Overall Growth of Business Activity
- regional output (business sales)
- gross regional product (value added)
- wages (personal income)
- jobs (employment)

Other Factors Affected as a Result of Economic Development
- property values
- land use/development
- environment
- government revenues & costs

[Source: Weisbrod, 2000]
Why Assess Econ. Dev. Effects?

- **Project planning/program development:**
  - Understand total impact of project proposals
  - Identify cost-effective projects
  - Efficient allocation of funds
  - Justify value of transportation investment
  - Public information
  - EIS (NEPA)

- **Decision-making in project selection**

- **Fulfilling federal requirements (SAFETEA-LU)**
How Do State Agencies Address Economic Development?
Economic Development Practices in US

- 28 States—econ. dev. hwy funding programs
- 11 States—policies: econ. dev. as a factor in project decision-making
- 11 States—no formal funding programs/policies
  - CA, CO and UT—policies in development

Objectives:
- Job, wage, and local tax growth
- Spur private sector investment
- Provide public hwy network to rural areas
- Retention of businesses
# Econ. Scoring Process

<table>
<thead>
<tr>
<th>DOT</th>
<th>Econ. Dev. Measures/Indicators</th>
<th>Weight</th>
</tr>
</thead>
</table>
| Wisconsin | • Cost per job created or retained  
               • Unemployment rate                                                   | 40%    |
| Iowa      | • Job creation or retention  
               • Funded dollars per job created or retained  
               • Tourism attraction  
               • Private investment                                                | 30%    |
| Ohio      | • Job creation  
               • Job retention  
               • Econ. distress  
               • Funded dollars per job created  
               • Private investment                                                | 30%    |
| Kansas    | • Strategic econ. corridor  
               • Econ. distress  
               • Supports regional econ. dev. plans                                | 20%    |
| Missouri  | • Strategic econ. corridor  
               • Econ. distress  
               • Supports regional econ. dev. plans                                | 15%    |
Past Research

- Early 1960s—focus on econ. dev. impacts of Interstate construction
- Since 1980s—focus on the link between hwys & econ. dev.
- 1990s—studies claimed substantial econ. growth impacts

* Aggregate historical data (cross-section/time-series)
* Assuming same intensity of highway use (traffic flows)
Motivation

- Econ. dev. effects vary among projects of different type and purpose. Depend on:
  - Hwy location
  - Economic interests served
  - Travel markets served
  - Accessibility and system-wide connectivity

- Limited research in the US dealing with specific facility type improvements

- Complexity of existing analytical methods
  - Excessive data requirements
  - Special staff training
Research Objectives

- Investigate relationship between highway investment and statewide economic development.
  - Nature of long-term economic development effects
  - Location and project-specific factors
  - Highway investments as a tool for expansion of job and income opportunities in IN
Research Objectives (cont’d)

**Project-level** easy-to-use quantitative tool

- Provide a credible foundation for hwy investment decisions on the basis of econ. dev. criteria
- Improve judgment of planners and decision-makers:
  - Will a hwy investment result in econ. dev.?
  - If so, to what extent?

- **General:** New construction vs. added capacity?
- **Specific:** Which particular projects to build? Where?
Highway Infrastructure

Economic Activity

Economic Development Effects of Highway Added-Capacity Projects

SPR-2861

Research Team

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SAC Meeting
April 30, 2006
Insights from Corridor Projects in IN

- **PROJECT LENGTH/COSTS (+)**
- **LOCATION**
  
  Linear Regression
  \[ R^2 = 0.953 \]
  \[ N = 21 \]

- **PROJECT LENGTH/COSTS (+)**
  **ECON. CENTER INDICATOR (+)**
  
  Linear Regression
  \[ R^2 = 0.732 \]
  \[ N = 17 \]

- **PROJECT LENGTH/COSTS (+)**
  **INTERSTATE INDICATOR (+)/LOCATION**
  
  Linear Regression
  \[ R^2 = 0.914 \]
  \[ N = 21 \]

Insights from Corridor Projects in IN

- Econ. dev. is driven by:
  - Project length/investment
  - Project location
  - Hwy functional class (i.e., interstate)

- Project type?
Type of Highway Improvement

Economic Activity

[Images of highways and economic activities]
Study Framework

1. **HIGHWAY IMPROVEMENTS**
   - **DETERMINE TRAVEL IMPACTS**
     - Travel Demand Model
2. **ESTIMATE USER BENEFITS**
   - Economic Impact Analysis Model
3. **ESTIMATE ECONOMIC BENEFITS**
   - Dynamic Economic Simulation Model

**ESTIMATE ECONOMIC BENEFITS BY HWY IMPROVEMENT AND PROJECT LOCATION**

**Econometric Models**
## Data–Hwy Improvements

<table>
<thead>
<tr>
<th>Project Type</th>
<th>Urban</th>
<th>Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Added Travel Lanes</td>
<td>27</td>
<td>31</td>
</tr>
<tr>
<td>Median Construction</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>New Road Construction</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td>Interchange Construction/Modification</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>62</strong></td>
<td><strong>55</strong></td>
</tr>
</tbody>
</table>
## Data (cont’d)

<table>
<thead>
<tr>
<th>Highway project-specific data</th>
<th>Location/ Accessibility/ Land use indices</th>
<th>Statewide long-term* econ. dev. benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Type</strong></td>
<td>• Geographical Region (North, Central, South IN)</td>
<td>• Net Change in Employment</td>
</tr>
<tr>
<td>• Added Travel Lanes</td>
<td>• County</td>
<td>• Net Change in Real Disposable Income</td>
</tr>
<tr>
<td>• New Construction/ Alignment</td>
<td>• District</td>
<td>• Net Change in Business Sales (Output)</td>
</tr>
<tr>
<td>• Median Construction</td>
<td>• MPO</td>
<td>• Net Change in GRP</td>
</tr>
<tr>
<td>• Interchange</td>
<td>• Type of Area (Urban/Rural)</td>
<td>* Over a 20-year period</td>
</tr>
<tr>
<td>Construction/Modification</td>
<td>• Accessibility to Major Airports</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Accessibility to Universities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Accessibility to Employment</td>
<td></td>
</tr>
<tr>
<td><strong>Project Size</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Project Length</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Number of Lanes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Hwy System</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Project Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Construction Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• ROW Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Engineering Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Duration of Construction (yrs.)</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Projects included in INDOT’s Long Range Transportation Plan (2000–2025)
Indiana County Classification
Data Sources

- **2025 Long Range Transportation Plan (INDOT)**
  - project ID, route, functional class
  - project type, size, costs (2003$)
  - district, MPO, county

- **2005 HPMS:**
  - highway geometrics, traffic operation data and design parameters
  - base year and 20-year forecast

- **2004 Statewide Reference Post Book (INDOT)**
Data Sources (cont’d)

- **Safety studies in Indiana** (Tarko and Kanodia, 2003; Tarko et al., 2000)
  - Safety performance functions
  - Crash costs in Indiana
  - Crash reduction factors by improvement type and type of area (urban/rural)

- **Safety Management System Software** (Lamptey et al., 2004)
  - Crash reduction factors by improvement type and type of area (urban/rural)
Data Sources (cont’d)

- Indiana’s economic profile
  - Employment by industry (BEA)
  - Location quotients (BLS-calculator)

- Automobile travel in Indiana
  - BTS
  - INDOT 1995 Travel Survey

- Indiana accessibility
  - Indiana Statewide Travel Demand Model (ISTDM)
Long-term Economic Benefit Estimation

1. HIGHWAY IMPROVEMENTS
2. DETERMINE TRAVEL IMPACTS
3. ESTIMATE USER BENEFITS
4. ESTIMATE DIRECT BUSINESS COST SAVINGS
5. ESTIMATE ECONOMIC BENEFITS
6. Location Quotient Analysis
7. Economic Impact Analysis Model
8. Travel Demand Model
9. Dynamic Economic Simulation Model (REMI)
<table>
<thead>
<tr>
<th>User Benefits</th>
<th>Business Cost Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Savings—business travel (&quot;on-the-clock&quot; worker time)</td>
<td>Value of additional productive labor hours (for non-salaried portion of workers)</td>
</tr>
<tr>
<td>Time Savings—other trips (includes commuting)</td>
<td>(May lead to additional spending or affects wages for recruiting workers)</td>
</tr>
<tr>
<td>Operating Cost Savings—business travel (pickups and deliveries)</td>
<td>Direct cost savings</td>
</tr>
<tr>
<td>Operating Cost Savings—other travel (includes commuting)</td>
<td>Increase in disposable personal income (May also affect wage rates)</td>
</tr>
<tr>
<td>Safety Improvements—business travel (&quot;on-the-clock&quot; worker time)</td>
<td>Reduction in insurance costs and worker absenteeism</td>
</tr>
<tr>
<td>Safety Improvements—other travel</td>
<td>Reduction in insurance cost, raising disposable income</td>
</tr>
</tbody>
</table>

Long-term Economic Benefit Estimation

1. **HIGHWAY IMPROVEMENTS**
   - DETERMINE TRAVEL IMPACTS
     - ESTIMATE USER BENEFITS
     - ESTIMATE DIRECT BUSINESS COST SAVINGS
     - ESTIMATE POTENTIAL BUSINESS ATTRACTION
     - ESTIMATE ECONOMIC BENEFITS

2. **Travel Demand Model**

3. **Location Quotient Analysis**

4. **Economic Impact Analysis Model**

5. **Dynamic Economic Simulation Model (REMI)**
Estimation of Potential Business Attraction

- **Business Attraction Impacts:**
  - Changes in employment by industry
  - Difficult to predict with accuracy

- **Methods:**
  - Business surveys or interviews
  - Non-survey methods
    - **Location quotient analysis**
      - ratio of an industry’s share of regional economy to the industry’s share of the state economy, in terms of employment
Estimation of Potential Business Attraction (cont’d)

- **Scenarios:**
  - No business attraction (Scenario 1)
  - Location quotient (LQ) analysis (CSI, 1998a; 1998b)
    - Proportional to business expansion by LQ (Scenario 2)
    - Proportional to business expansion by 1/LQ (Scenario 3)
Long-term Economic Benefit Estimation

- **HIGHWAY IMPROVEMENTS** → **DETERMINE TRAVEL IMPACTS** → **ESTIMATE USER BENEFITS**
  - Economic Impact Analysis Model

- **ESTIMATE DIRECT BUSINESS COST SAVINGS**
  - Dynamic Economic Simulation Model (REMI)

- **ESTIMATE POTENTIAL BUSINESS ATTRACTION**
  - Location Quotient Analyses

- Travel Demand Model
Economic Simulation Model

- **REMI**: links an econometric model to an I-O model
  - Dynamic/long-term effects
  - Suitable for estimating impacts resulting from transportation investments
  - Provide wide range of outputs
  - Calibrated for IN
Understanding the Model

Econometric Analysis

- **HIGHWAY IMPROVEMENTS**
- **DETERMINE TRAVEL IMPACTS**
  - Travel Demand Model
- **ESTIMATE USER BENEFITS**
  - Economic Impact Analysis Model
- **ESTIMATE ECONOMIC BENEFITS**
  - Dynamic Economic Simulation Model

**ESTIMATE ECONOMIC BENEFITS BY HWY IMPROVEMENT AND PROJECT LOCATION**

**Econometric Models**
Variables

- **Dependent variables (REMI outputs):**
  - Net statewide cumulative change over 20 years in:
    - employment (jobs)
    - real disposable income
    - output
    - GRP
  - Under 3 different scenarios of business attraction
    - Scenario 1 (lower estimates)
    - Scenario 2
    - Scenario 3 (higher estimates)
Variables (cont’d)

- Econ. dev. benefit/cost ratios
  - Jobs/million $ of hwy spending
  - Income/million $ of hwy spending
  - Output/million $ of hwy spending
  - GRP/million $ of hwy spending

- Independent variables (data collection):
  - Project and location-specific attributes
Methodology

Econometric Analysis of Regional Systems

- **Single regression equation**
  - Unrelated behavior of dependent variables
  - OLS estimation
  - Parameter estimates consistent but not efficient

- **System of regression equations**
  - Joint behavior of dependent variables
  - GLS estimation
  - Parameter estimates consistent and efficient
  - Lower variance estimates than single-equation methods
Methodology (cont’d)

SURE model

$M$ seemingly uncorrelated equations:

$$y_i = X_i \cdot \beta_i + \varepsilon_i, \quad i = 1, \ldots, M$$

- $y_i$ \quad $T \times 1$ vector of observed values on the $i$-th dependent variable
- $X_i$ \quad $T \times p_i$ matrix with rank $p_i$ of observations on $p_i$ independent variables
- $\beta_i$ \quad $p_i \times 1$ vector of unknown regression coefficients
- $\varepsilon_i$ \quad $T \times 1$ vector of error terms, $E(\varepsilon) = 0$, $E(\varepsilon\varepsilon') = \Sigma \otimes I_T$

Simultaneous correlation of the error terms

Using GLS, $$\hat{\beta} = \left( X'(\Sigma \otimes I_T)^{-1} \cdot X \right)^{-1} \cdot X'(\Sigma \otimes I_T)^{-1} \cdot Y$$
Methodology (cont’d)

Chow test (1960)

\[ F_{k,N_1+N_2-2k} = \frac{RSS_r - RSS_{ur}}{k} \frac{RSS_{ur}}{N_1 + N_2 - 2k} \]

- \( RSS_r \): residual sum of squares for the restricted model
- \( RSS_{ur} \): residual sum of squares for the unrestricted model
- \( N_1, N_2 \): number of observations in each sub-sample
- \( k \): number of restrictions to be tested

Data cannot be pooled when \( F_{stat} > F_{k,N_1 + N_2 - 2k} \)
Chow Test Results

Separate models for:

- Added travel lanes projects (58 obs.)
- New construction-related projects (59 obs.):
  - New road construction
  - Median construction
  - Interchange construction
Methodology (cont’d)

Student’s $t$-test (1908)

- Scenarios 2 & 3 not significantly different
- Separate models for:
  - estimates under 2 scenarios
Methodology (cont’d)

Durbin–Watson statistic (1950)

- Separate indicator variables for projects in:
  - Marion County
    - 12.8%—total
    - 22.4%—ATL
  - Other urban areas
Equation 1: Net change in employment (jobs)
Equation 2: Net change in real disposable income
Equation 3: Net change in output
Equation 4: Net change in GRP

- 2 GROUPS OF PROJECTS
- 2 SCENARIOS (low/high)
SUR Equation System II

Equation 1: Jobs/million $ of spending
Equation 2: Real disposable income/million $
Equation 3: Output/million $ of spending
Equation 4: GRP/million $ of spending

• 2 GROUPS OF PROJECTS
• 2 SCENARIOS (low/high)
Adding Travel Lanes

Economic Activity
Equation 1–Jobs

\[ REMIEMP = -156.0 + 10.56 \cdot NEWLNMI \]
\[-168.4 \cdot URBAN + 347.2 \cdot I \]
\[ + 43.75 \cdot ACCAIRP - 90.86 \cdot CENTRAL \]

\( (Adjusted \ R^2 = 0.55) \)

- **REMIEMP**: net change in employment (jobs)
- **NEWLNMI**: new (added) lane-miles
- **URBAN**: 1, if project in urban areas; 0, for rural
- **I**: 1, for interstate hwy; 0, otherwise
- **ACCAIRP**: accessibility to major airports (1 to 5)
- **CENTRAL**: 1, if project in central IN; 0, otherwise
Analysis Results

- Potential greater econ. dev. benefits from investments in:
  - Interstate hwys in rural North or South IN with a high degree of accessibility to airports
  - Hwys located in Marion County compared to the other urban areas

- Potential lower econ. dev. benefits from investments in:
  - State hwys in rural areas in Central IN
  - Urban areas with low connectivity to airports, universities or employment
Median Construction
New Road Construction

Interchange Construction/Modification

Economic Activity
Equation 2–Income

\[
REMINCMI = 2.14 + 0.28 \cdot PRLENNRC + 19.37 \cdot I \\
+ 19.34 \cdot ACCEMPI45 + 0.65 \cdot URBU \\
- 0.60 \cdot MC - 0.67 \cdot STNRC
\]

(Adjusted \( R^2 = 0.66 \))

**REMINCMI**  net change in real disposable income (million 1996$)  
**PRLENNRC**  project length in miles for NRC projects  
**I**  1, for interstate hwy; 0, otherwise  
**ACCEMPI45**  accessibility to employment of IC projects (4 to 5)  
**URBU**  1, if project located on urban US hwy; 0, otherwise  
**MC**  1, for median construction projects; 0, otherwise  
**STNRC**  1, if NRC project located on State hwy; 0, otherwise
Equation 2–Income

\[ \text{INCPER96$} = 0.41 + 0.84 \cdot I + 1.72 \cdot \text{ACCEMPI45} - 0.26 \cdot \text{URBAN} \]

(Adjusted \( R^2 = 0.60 \))

\( \text{INCPER96$} \) net change in real disposable income / million 1996$

\( I \) 1, for interstate hwy; 0, otherwise

\( \text{ACCEMPI45} \) accessibility to employment of IC projects (4 to 5)

\( \text{URBAN} \) 1, if project in urban areas; 0, for rural
Analysis Results

Potential greater econ. dev. benefits from:

- Construction of Interstate hwy interchanges with a high degree of accessibility to employment
- New road construction projects programmed for US highways in South IN

Potential lower econ. dev. benefits from:

- Median construction projects
- New road construction projects on state roads in North or Central IN
- Investments in urban areas compared to rural areas
“Validation” of Analysis Results

<table>
<thead>
<tr>
<th>Long-term Statewide Cumulative Net Change in:</th>
<th>INDOT&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Research Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employment (jobs)</td>
<td>15,050</td>
<td>9,850–20,950</td>
</tr>
<tr>
<td>Income (billions of 2000 dollars)</td>
<td>1.1</td>
<td>1.8–3.4</td>
</tr>
<tr>
<td>Output (billions of 2000 dollars)</td>
<td>4.0</td>
<td>3.8–6.3</td>
</tr>
</tbody>
</table>

<sup>a</sup> CSI and BLA, “Economic Impacts of Indiana’s Statewide Long-Range Transportation Plan.” Prepared for INDOT, 2004.
Conclusions

- Hwy investment can have a positive impact on IN economy
  - Project-specific factors
  - Economic conditions of the region

- Significant determinants:
  - Size of hwy investment (↑)
  - Hwy functional class [Interstate (+)]
  - Type of area [rural (+), Marion County (+)]
  - Degree of accessibility to airports/employment (↑)
Conclusions (cont’d)

- Greater potential for long-term statewide economic development effects from:
  - Capacity improvements (especially on interstates)
  - Interchange construction
  - New road construction projects of greater size
  - In rural areas in North or South IN
  - In urban areas in Central IN (especially in Marion County)
Conclusions (cont’d)

- Transportation necessary but not sufficient factor
  - Hwy access only one factor in the complexity of business location decisions

- Ideally, empirical data analysis of actual effects of different hwy improvements (ex-post evaluation)

- Consideration of:
  - Transportation performance (intensity of use)
  - Different scenarios of business attraction
  - Dynamic & ripple effects
Conclusions (cont’d)

Econometric analysis framework

- System of regression equations:
  - (Indirect) interaction of 4 econ. dev. measures
  - GLS estimation vs. OLS estimates
  - Parameter estimates consistent and efficient
  - Lower variance estimates than single-equation methods
  - Valid inferences
Implementation

Easy-to-use quantitative tool
at the project development phase

- Assist planners and decision-makers to:
  - Make order-of-magnitude comparisons of benefits and costs
  - Identify possible cost-effective investments
  - Identify possible important benefit areas
Implementation (cont’d)

**INPUTS**
- TYPE
- LENGTH/LANES
- COSTS
- HWY CLASS
- LOCATION

**SUR Equations**

**OUTPUTS**

LOW/HIGH ESTIMATES OF STATEWIDE LONG-TERM CHANGE IN:
- JOBS
- INCOME
- OUTPUT
- GRP
- JOBS/$
- INCOME/$
- OUTPUT/$
- GRP/$
Implementation (cont’d)

- **Project Ranking/Prioritization**
  - B/C method
    - Measure econ. dev. benefits as changes in real disposable income
    - Separately estimate user benefits for non-business/personal travel
    - Add benefits and compute B/C ratio
  - Scoring method
    - Use EDB/C ratios to assign scores to projects according to their econ. dev. potential
Future Research

- Development of improved data on regional accessibility & changes in accessibility resulting from hwy improvements
- Estimation of spatial econometric models
- Validation of the scoring method using expert opinions/panels
Acknowledgements

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- Professor Fred L. Mannering
- Joint Transportation Research Program (JTRP)
  - Indiana Department of Transportation (INDOT)
  - Purdue University, School of Civil Engineering
Awards/Publications


THANK YOU!
1. System Planning
2. Project Development
3. Mitigation
4. ROW Studies

Evaluation of Alternative System Plans and Policies
Evaluation of Alternative Location Plans
Evaluation of Alternative System Designs
Evaluation of Alternative Construction Practices
Evaluation of Alternative Operation Policies and Regulations
Evaluation of Alternative Preservation Practices

5. Construction

6. System Operation

For Existing System

For Similar Future Systems

7. System Preservation

8. System Performance Evaluation and Feedback
Indiana Accessibility to Airports