Economic Development Effects of Highway Investment

Nadia Gkritza, Ph.D.

Assistant Professor
Iowa State University

TRANS 691 Seminar

February 13, 2009

Outline

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

Introduction

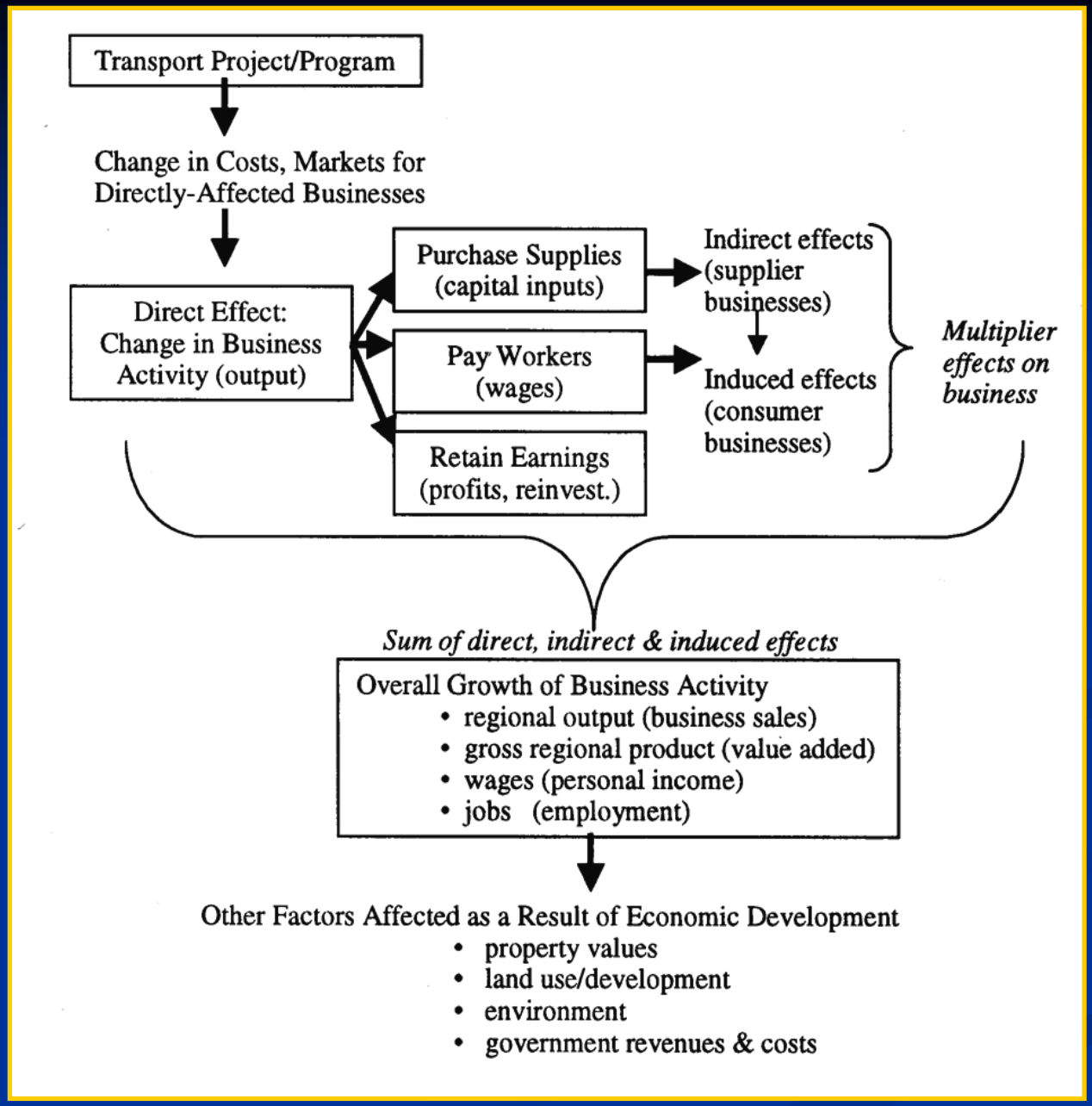
- **Economic Analysis:**
  - Benefits and costs to society
  - Impacts on:
    - Transportation system users *(travel time, safety, VOC)*
    - Environment *(noise, emissions, energy)*
    - Economic development

Introduction (cont'd)

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

Econ. Dev. Effects

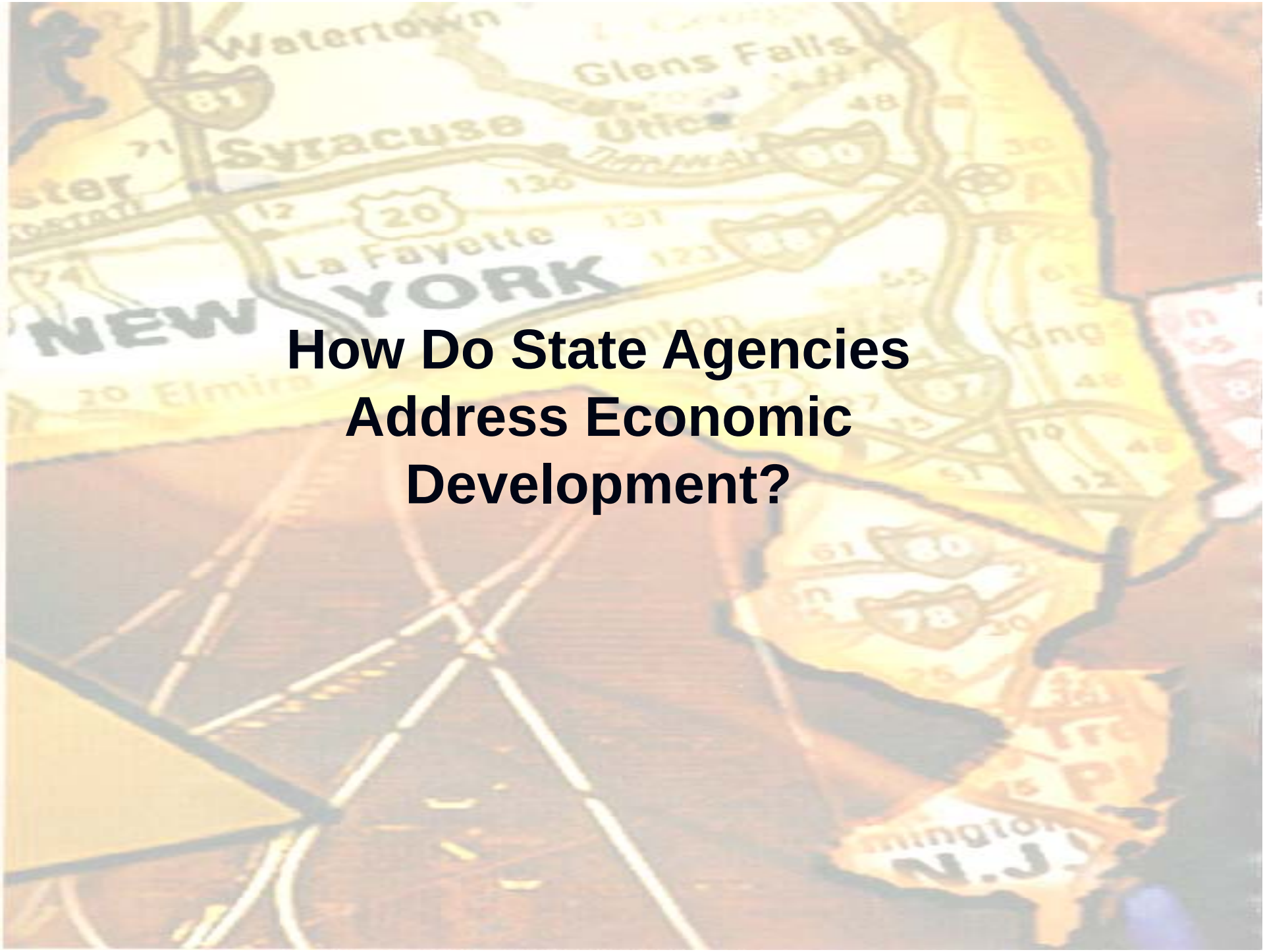
- **Direct**
- **Indirect**
- **Induced**
- **Multiplier Effects: indirect & induced effects**
- **Static (no time dimension)**
- **Dynamic (long-term)**



[Source: Weisbrod, 2000]

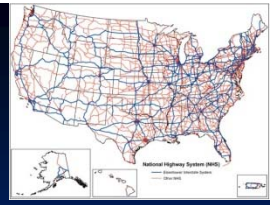
Why Assess Econ. Dev. Effects?

- **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

DOT	Econ. Dev. Measures/Indicators	Weight
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		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

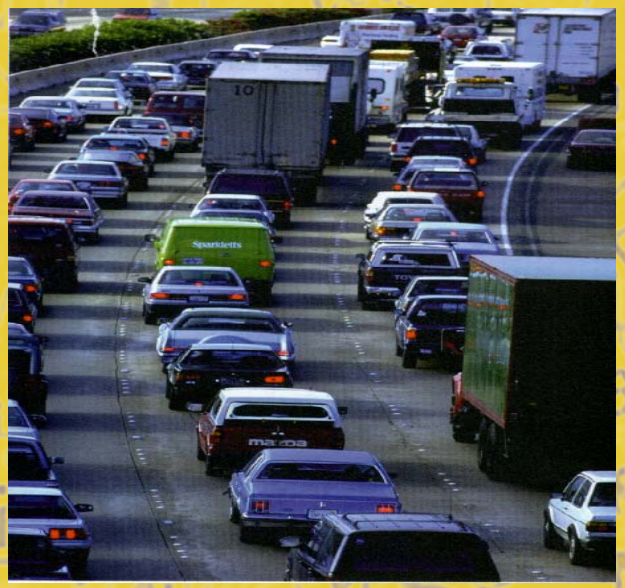
- **Investigate relationship between hwy investment and statewide econ. dev.**
  - Nature of long-term econ. dev. effects
  - Location and project-specific factors
  - Hwy investments as a tool for expansion of job and income opportunities in IN

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

Insights from Corridor Projects in IN

- **PROJECT LENGTH/COSTS (+)**
- **LOCATION**

Linear Regression
R^2 = 0.953
N = 21

→ **LONG-TERM CHANGE IN EARNINGS**

- **PROJECT LENGTH/COSTS (+)**
- **ECON. CENTER INDICATOR (+)**

Linear Regression
R^2 = 0.732
N = 17

→ **LONG-TERM CHANGE IN BUSINESS SALES**

- **PROJECT LENGTH/COSTS (+)**
- **INTERSTATE INDICATOR (+)/ LOCATION**

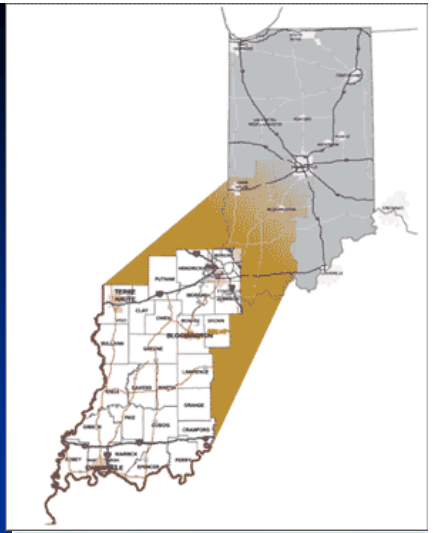
Linear Regression
R^2 = 0.914
N = 21

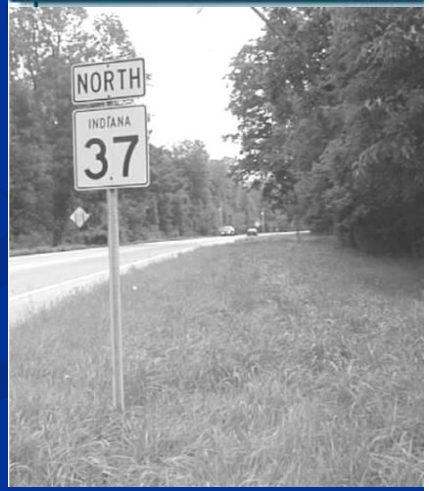
→ **LONG-TERM CHANGE IN EMPLOYMENT**

Ongoing (I-69/SR37/SR101) & Past Corridor Projects (US31/SR26&US35)

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

Study Framework

HIGHWAY IMPROVEMENTS → **DETERMINE TRAVEL IMPACTS** → **ESTIMATE USER BENEFITS** → **ESTIMATE ECONOMIC BENEFITS**

Travel Demand Model

Economic Impact Analysis Model

Dynamic Economic Simulation Model

ESTIMATE ECONOMIC BENEFITS BY HWY IMPROVEMENT AND PROJECT LOCATION

Econometric Models

Data–Hwy Improvements

	Urban	Rural
Added Travel Lanes	27	31
Median Construction	20	4
New Road Construction	8	18
Interchange Construction/ Modification	7	2
Total	**62**	**55**

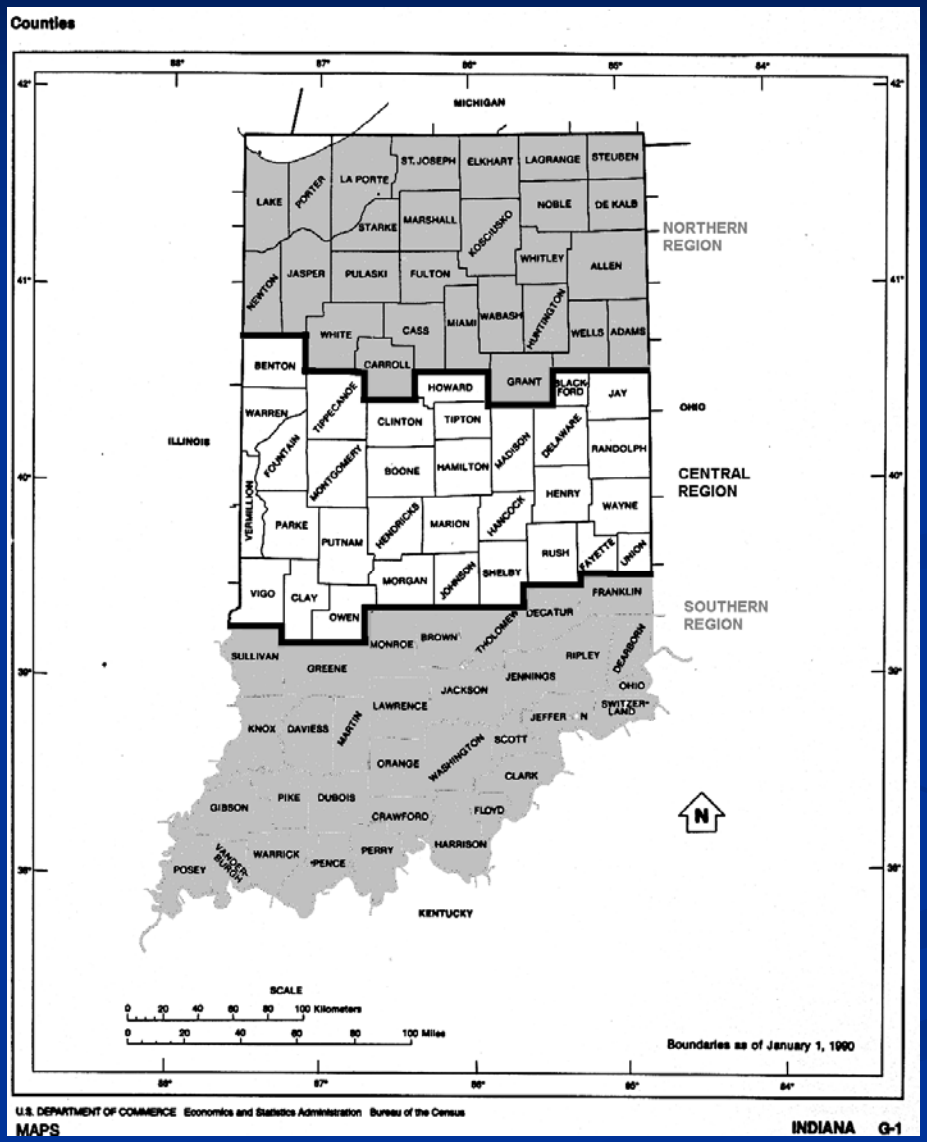
Projects included in INDOT's Long Range Transportation Plan (2000–2025)

Data (cont'd)

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

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

HIGHWAY IMPROVEMENTS → **DETERMINE TRAVEL IMPACTS** → **ESTIMATE USER BENEFITS**

Travel Demand Model

Economic Impact Analysis Model

ESTIMATE DIRECT BUSINESS COST SAVINGS

Location Quotient Analysis

ESTIMATE POTENTIAL BUSINESS ATTRACTION

ESTIMATE ECONOMIC BENEFITS

Dynamic Economic Simulation Model (REMI)

User Benefits	Business Cost Savings
Time Savings—business travel ("on-the-clock" worker time)	Value of additional productive labor hours (for non-salaried portion of workers)
Time Savings—other trips (includes commuting)	(May lead to additional spending or affects wages for recruiting workers)
Operating Cost Savings—business travel (pickups and deliveries)	Direct cost savings
Operating Cost Savings—other travel (includes commuting)	Increase in disposable personal income (May also affect wage rates)
Safety Improvements—business travel ("on-the-clock" worker time)	Reduction in insurance costs and worker absenteeism
Safety Improvements—other travel	Reduction in insurance cost, raising disposable income

Weisbrod, G. and B. Weisbrod. "Transportation Research Circular 477", TRB, National Research Council, Washington, D.C., 1997.

Long-term Economic Benefit Estimation

HIGHWAY IMPROVEMENTS → **DETERMINE TRAVEL IMPACTS** → **ESTIMATE USER BENEFITS**

Travel Demand Model

Economic Impact Analysis Model

ESTIMATE DIRECT BUSINESS COST SAVINGS

Location Quotient Analysis

ESTIMATE POTENTIAL BUSINESS ATTRACTION

ESTIMATE ECONOMIC BENEFITS

Dynamic Economic Simulation Model (REMI)

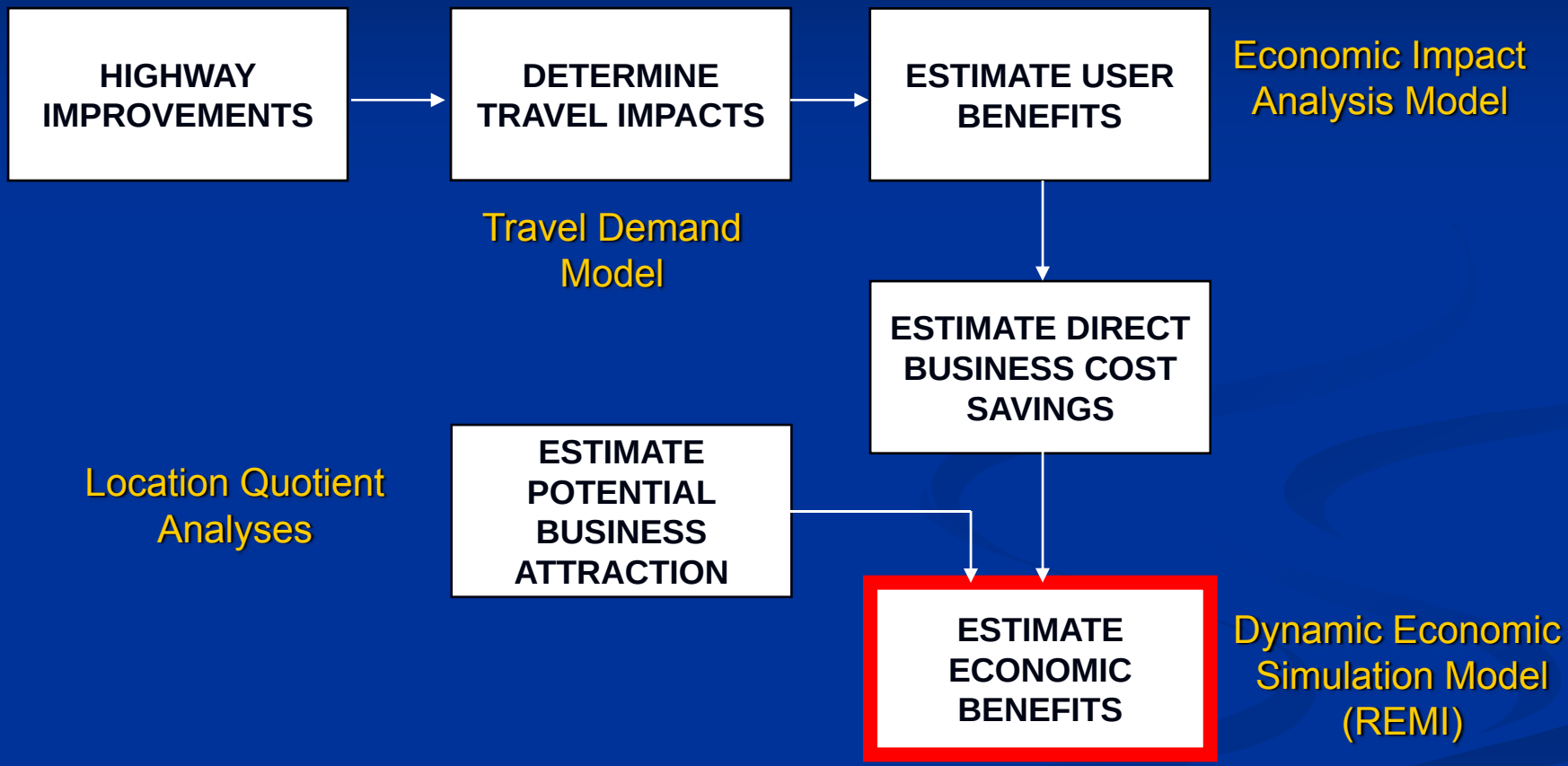
Estimation of Potential Business Attraction

- **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)

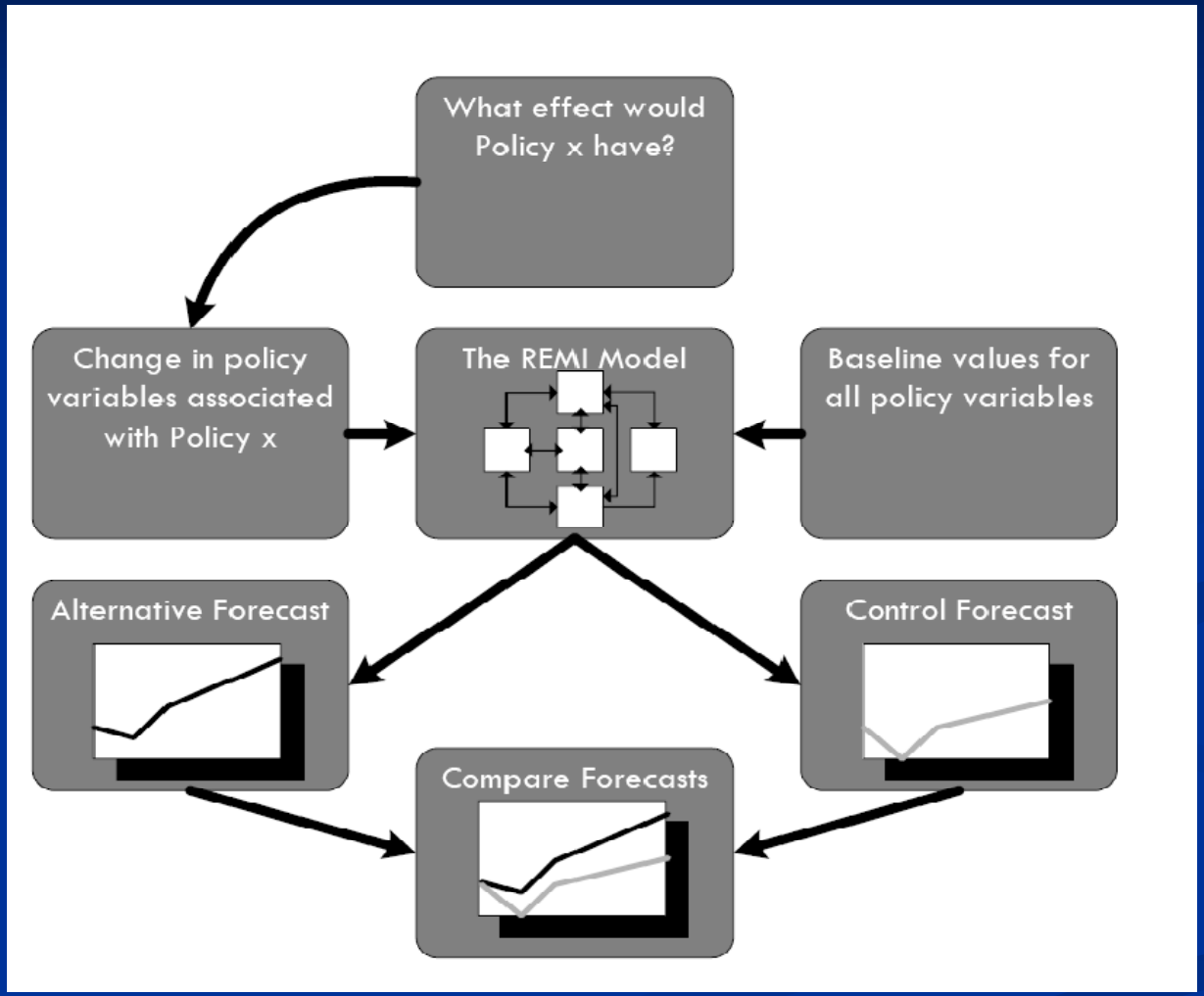
Long-term Economic Benefit Estimation



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



Treyz F. and G. Treyz. "REMI Policy Insight Model Documentation Version 6.0." Regional Economic Models, Inc., Amherst, Massachusetts, 2002.

Econometric Analysis

HIGHWAY IMPROVEMENTS → **DETERMINE TRAVEL IMPACTS** → **ESTIMATE USER BENEFITS** → **ESTIMATE ECONOMIC BENEFITS**

Travel Demand Model

Economic Impact Analysis Model

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:

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

y_i $T \times 1$ vector of observed values on the i-th dependent variable

X_i $T \times p_i$ matrix with rank p_i of observations on p_i independent variables

β_i $p_i \times 1$ vector of unknown regression coefficients

ε_i $T \times 1$ vector of error terms, $E(\varepsilon) = 0$, $E(\varepsilon\varepsilon') = \Sigma \otimes I_T$

Simultaneous correlation of the error terms

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

Methodology (cont'd)

Chow test (1960)

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

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 $F_{stat} > \mathrm{F}_{k,N1\ +\ N2\ -\ 2k}$

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

SUR Equation System I

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

?

Economic Activity

Interchange Construction/ Modification

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

$$INCPER96\$ = 0.41 + 0.84 \cdot I + 1.72 \cdot ACCEMPI45 - 0.26 \cdot URBAN$$

(*Adjusted* $R^2 = 0.60$)

INCPER96$	net change in real disposable income / million 1996$
I	1, for interstate hwy; 0, otherwise
ACCEMPI45	accessibility to employment of IC projects (4 to 5)
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

Long-term Statewide Cumulative Net Change in:	**INDOT[a]**	**Research Study**
Employment (jobs)	15,050	9,850–20,950
Income (billions of 2000 dollars)	1.1	1.8–3.4
Output (billions of 2000 dollars)	4.0	3.8–6.3

[a] 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 econ. 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

- Olson Distinguished Professor Kumares C. Sinha
- Professor Fred L. Mannering

- Joint Transportation Research Program (JTRP)
  - Indiana Department of Transportation (INDOT)
  - Purdue University, School of Civil Engineering

Awards/Publications

C.V. Wootan Memorial Award for outstanding Ph.D. dissertation in Policy and Planning, Council of University Transportation Centers, 2007.

Gkritza, K., S. Labi, F.L. Mannering and K.C. Sinha (2008). Influence of highway construction projects on economic development: An empirical assessment. *The Annals of Regional Science*, Vol. 42(3): 545–563.

Gkritza, K., K.C. Sinha, S. Labi, and F.L. Mannering (2008). Economic development and highway project decision-making. Presented at the *10th International Conference on Application of Advanced Technologies in Transportation*, May 27–31, Athens, Greece.

THANK YOU!

Evaluation of Alternative System Plans and Policies

1. System Planning

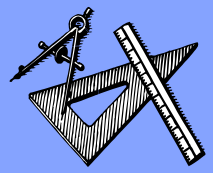
Evaluation of Alternative Location Plans

2. Project Development

3. Mitigation

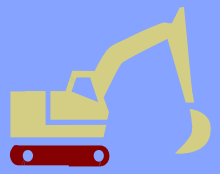
4. ROW Studies

Evaluation of Alternative System Designs



4. System Design

Evaluation of Alternative Construction Practices



5. Construction

Evaluation of Alternative Operation Policies and Regulations

6. System Operation

Evaluation of Alternative Preservation Practices

7. System Preservation

For Existing System

For Similar Future Systems

8. System Performance Evaluation and Feedback

Indiana Accessibility to Airports