# CAPTURING CHANGES IN INVESTMENT, DEMAND AND POLICY USING THE TRANSPORTATION PERFORMANCE INDEX

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## ABSTRACT

Transportation infrastructure supports economic health and competitiveness. While past studies have focused on the relationship between infrastructure expenditures and economic growth, this study uses the Transportation Performance Index, an aggregate measure of performance indicators for supply, quality of service and utilization for different modes. This paper demonstrates the role of the Transportation Performance Index in capturing changes in infrastructure supply and demand, and explores how these changes are influenced by transport policy. Prospective and retrospective analyses of different scenarios demonstrate the need for systemic, comprehensive and timely transportation infrastructure improvement.

*Keywords: performance, infrastructure, economic productivity*

## INTRODUCTION

Transportation infrastructure is understood to be a foundation for economic health and competitiveness. However, no study has taken a comprehensive, quantitative look at transportation infrastructure performance over time. The American Society of Civil Engineers' (ASCE) Report Card is a qualitative presentation of the state of US infrastructure based on data and expert judgment (ASCE, 2010). More recently, ASCE has attempted to link this analysis to economic health (ASCE, 2011). Other studies have focused on trying to correlate infrastructure expenditure, rather than infrastructure performance, with economic productivity. A recent review of such studies (Shatz et al, 2011) confirms the positive relationship between infrastructure and economic growth. These studies capture the positive and significant direct and indirect impacts of transportation investment including the condition of the infrastructure as well as network effects. The complexities involved in these relationships mean that it is particularly difficult to understand the causal interactions. Cost benefit analysis based on microeconomic analysis does not capture the network effects. Macroeconomic analysis requires more than a simple production function but a general equilibrium model (Lakshmanan, 2011). The difficulties in formulating and calibrating such a model are daunting. As an alternative approach, this study uses the Transportation Performance Index to better understand what it takes to significantly improve the performance of transportation infrastructure in the United States.

### Objective

Our objective is to demonstrate the role of the Transportation Performance Index in capturing changes in infrastructure supply and demand to influence transport policy. The paper begins by describing how the index was constructed using a replicable and transparent process and discusses the limitations of both the process and the data. The numerical results for the index itself are then presented showing that over the last two decades there has been little change in the index despite growing awareness of aging infrastructure, improved operations, and greater investment in infrastructure. Finally, the role of the index in communicating national needs and the importance of infrastructure are discussed.

## BACKGROUND

This paper draws on a project funded by the US Chamber of Commerce Foundation. The project developed an annual Transportation Performance Index for the United States for the period 1990 to 2009, and related the index to economic growth and productivity. Specifically, relationships between transportation infrastructure performance and per capita economic growth, and transportation infrastructure performance and foreign direct investment have been demonstrated.

The Transportation Performance Index is based on the following steps (US Chamber of Commerce, 2010):

1. Definition of the transportation sector – The transportation sector is defined as “the fixed facilities (roadway segments, railway tracks, transit terminals, harbors, and airports), flow entities (people, vehicles, container units, railroad cars), and control systems that permit people and goods to transverse geographical space efficiently and in a timely manner in some desired activity. Transportation is provided by modes – highway, rail, air, and marine.” (US Chamber of Commerce, 2010).

2. A representative sample of Metropolitan Statistical Areas (MSAs) – Thirty six (36) MSAs were selected to represent different sectors of the economy, population size and geography. These MSAs represent approximately 80% of the US economy measured by gross domestic product.

3. A hierarchical model - This models captures:

   - The size of the MSAs: population greater than and population less than 1 million
   - The different modes: highway, rail, transit, air, and water/port
   - Criteria for measuring performance: supply, quality of service and utilization.

4. Identification of indicators – Twenty-one (21) indicators were selected to represent transportation infrastructure performance (Li et al, 2011). To serve as a candidate indicator, the indicator must have publically available data and cover most of the period 1990 to present. The list of indicators is shown in Table 1.

5. Data collection – Data are assembled and normalized to ensure a consistent scale for each indicator.

6. Weighting of indicators – Weights were developed based on a survey of stakeholders using the analytic hierarchy process (AHP).

7. Calculation of index – The index is computed for each year using the value of each indicator in that year for each MSA and weighting the indicator by the values determined using the AHP and by the relative contribution of each MSA to the economy. Below are the technical specifications used to calculate the Transportation Performance Index (US Chamber of Commerce, 2010):

   $\text{Index}_{\text{Tran}}$ =

   $$= \sum_k \left[\sum_{i=1}^{I_k}\left(\left(\sum_{j=1}^{J} w_{jk}N_{ij}\right) e_{ik}\right)\left(\frac{\sum_{p=1}^{P_k} e_{pk}}{\sum_{i=1}^{I_k} e_{ik}}\right)\right]$$

   Where

   $k = 1 \ldots . K \ is\ the\ MSA\ type$

   $p = 1 \ldots . P_k \ is\ the\ MSA$ in the population of type k

   $i = 1 \ldots . I_k \ is\ the\ MSA$ in the sample of type k

   $e_{ik} = contribution\ of\ MSA\ i\ of\ type\ k\ to\ US\ economy$

   $\dfrac{\sum_{p=1}^{P_k} e_{pk}}{\sum_{i=1}^{I_k} e_{ik}} = economic\ expansion\ factor$

   $j = 1 \ldots J\ is\ the\ indicator$

   $w_{jk} = weight\ for\ indicator\ j\ in\ type\ k$

   $N_{ij} = normalized\ measure\ of\ indicator\ j\ for\ MSA\ i$

The weights are based on survey data (US Chamber of Commerce, 2010). The resulting Transportation Performance Index (TPI) from 1990 to 2009 is shown in Figure 1. The TPI values range from a low of 48.17 in 1990 to a high of 56.60 in 2009. As shown in Figure 1, the index sharply increased in 2009.

From analysis of the TPI results, the following observations can be made (US Chamber of Commerce, 2010):

- The TPI was constructed to estimate transportation infrastructure performance within plus or minus 2.5 points with a 95% level of confidence. To be significant, fluctuations need to be more than plus or minus one point.

- At the beginning of the 1990's, the TPI trended upward but fluctuations tended to be of the order of one or two points.

- In the three years since 2007, the TPI has again trended upward. This appears to be linked to the downturn in the economy and the associated reduction in congestion.

- No one project, investment in a single region or a single mode, will significantly change the value of the TPI.

- The TPI is based on indicators. Attempting to improve indicators rather than the overall performance of the system will not reflect the actual performance of the system.

- The TPI is sensitive to the variables with the largest weights – highway utilization, and travel time reliability – both indicators reflecting congestion.

Table 1- Performance Indicators Used in the TPI

| | Mode | # | Description | Measure |
|---|---|---|---|---|
| Supply | Highway | IND1 | Highway Density (Availability of highways) | Route-miles per 10,000 population |
| | Transit | IND2 | Density (Availability of transit) | Miles of transit per 10,000 population |
| | Air | IND3 | Access (Proximity of airports) | Percent of population within 50 miles of major airport(s) |
| | | IND4 | Capacity (Availability of airport service) | Airport arrival rate and departure rate per hour |
| | Rail | IND5 | Density (Availability of railroads) | Route-miles per 10,000 population |
| | Marine | IND6 | Density (Availability of marine) | Miles of waterways per 10,000 population |
| | | IND7 | Port Access (Proximity of ports) | Distance from the centre of MSA to the closest international container port |
| | Intermodal | IND8 | Freight Access (Proximity of intermodal facilities) | Number of facilities per 10,000 population |
| Quality of Service | Highway | IND9 | Travel Time Reliability (Variability in travel time due to congestion) | Travel Time Index |
| | | IND10 | Safety (Fatal highway crashes) | Fatalities per 100 million Vehicle Miles Travelled |
| | | IND11 | Road Roughness (Highway ride comfort) | Percent of lane miles in poor or fair condition (based on an International Roughness Index greater than 170 in/mi) |
| | | IND12 | Bridge Integrity (Ability of bridges to meet the needs of the users) | Percent of bridges structurally deficient or functionally obsolete |
| | Transit | IND13 | Safety (Transit incidents) | Number of incidents per million Passenger Miles Travelled |
| | Aviation | IND14 | Congestion (Airport congestion) | Percent of on-time performance for departures |
| | | IND15 | Safety (Chances of crashes) | Runway incursions per million operations |
| | Rail | IND16 | Safety (Railroad incidents) | Number of incidents per million train miles |
| | Marine | IND17 | Congestion (Delays on inland waterway) | Average lock delay per tow |
| Utilization | Highway | IND18 | Reserve capacity | Percent of lane miles uncongested defined as Level of Service (LOS) C or better |
| | Transit | IND19 | Reserve capacity | Passenger miles travelled per capacity (standing and seating) |
| | Aviation | IND20 | Reserve capacity | Percent of capacity used between 7 am and 9 pm |
| | Rail | IND21 | Reserve capacity | Ton-miles per track mile |

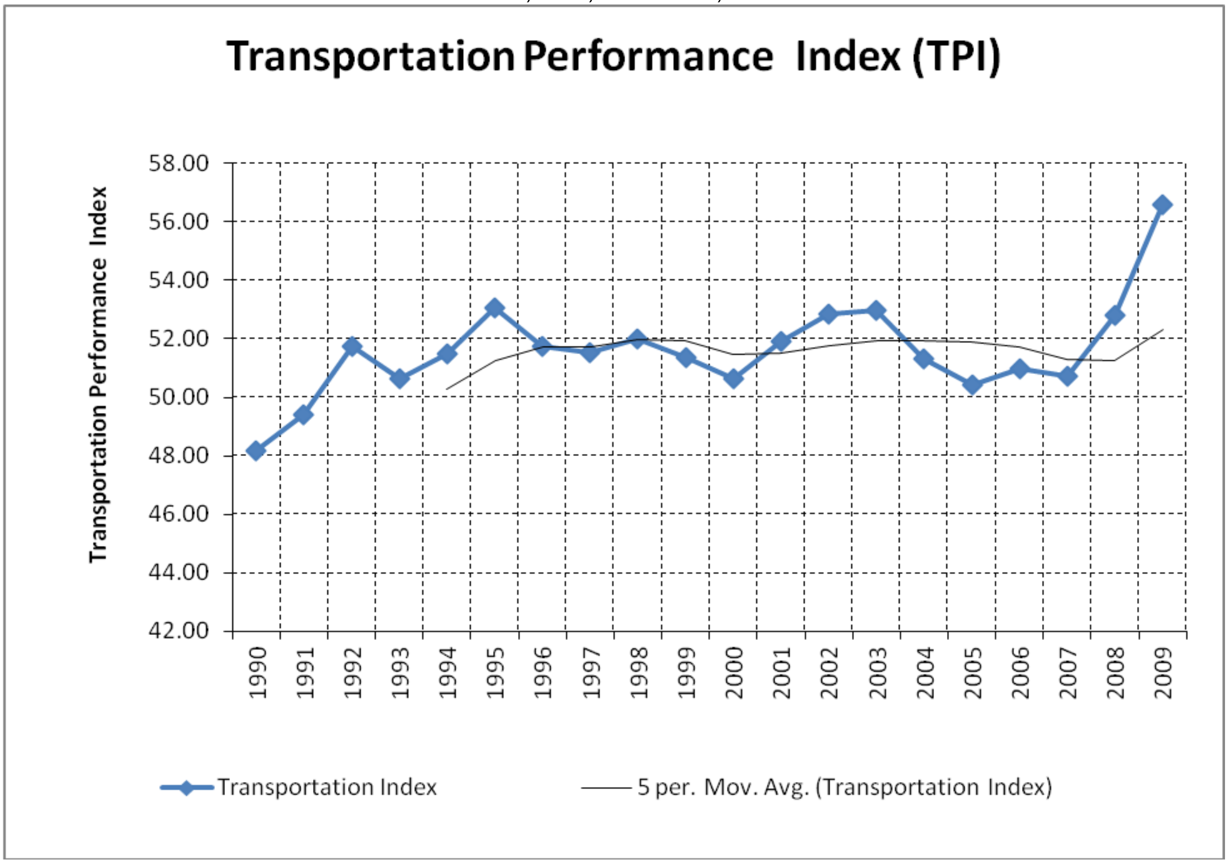


Figure 1 – Transportation Performance Index (1990-2009)

## Comparison with Other Measures

To better understand the changes in the TPI, we compare the time series of TPI data from 1990 to 2009 with the times series of Federal Transportation Expenditures (Figure 2), as well as a computed grade point average using the data from the ASCE Report Card over a similar time period (Figure 3).

Figure 2 shows Federal Transportation Expenditures in 2000 constant dollars. Data are obtained from the federal budget (Office of Management and Budget, 2010) and are deflated using a highway construction cost index (FHWA, 2013). In the TPI: Complete Technical Report, this process is documented in more detail (US Chamber of Commerce, 2010).

The peak expenditure occurs around 2002 when the economy was booming and significant investments were being made in transportation infrastructure supported by TEA-21. The sharp increase in expenditures in 2009 reflects “stimulus spending,” some of which may have been used by state and local governments to improve transportation infrastructure performance.

While the TPI is correlated with the federal expenditures, one would expect a lag between expenditures and improvements in performance. Furthermore, federal expenditures are a relatively small proportion of transportation investments.

As stated previously, the TPI is also compared to the ASCE Report Card (ASCE, 2010) as shown in Figure 3. The letter grades used in the report card are converted to the grade point average (GPA) by assigning a value of “4” to an “A” and a value of “0” to “F”. The differences in the trends reinforce the different emphases used to develop the two assessments. The TPI focuses on transportation performance in terms of how the infrastructure provides service, whereas the ASCE Report Card focuses on the structural condition of the physical infrastructure.

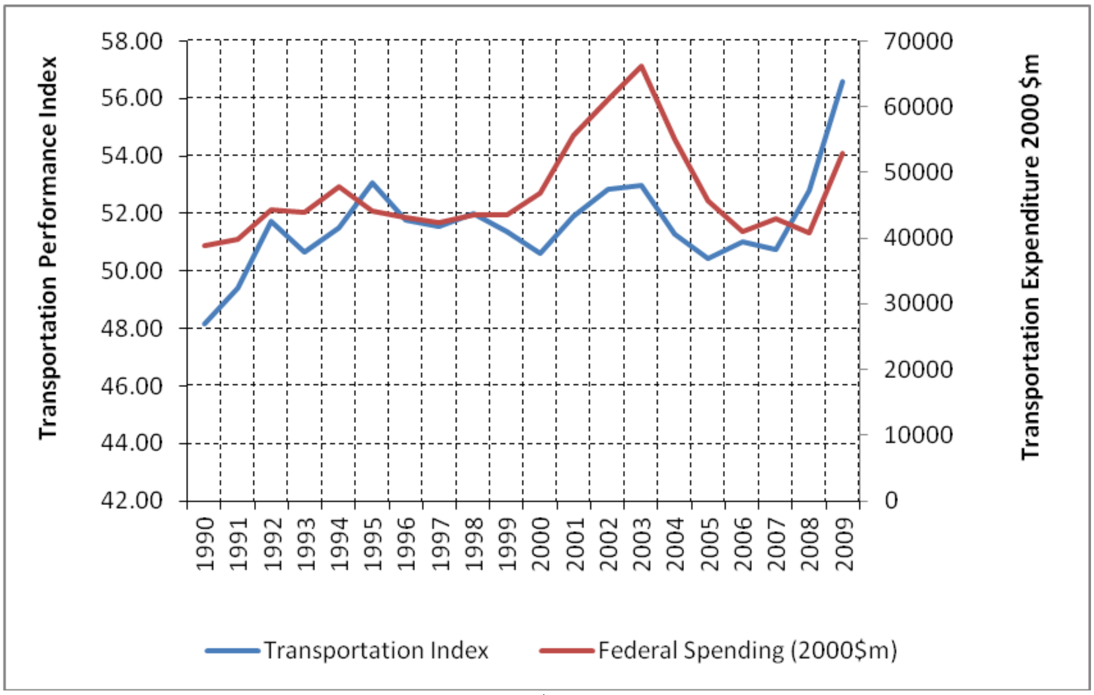


Figure 2 – Federal Transportation Expenditures (2000 $m) and Transportation Performance Index (1990-2009)

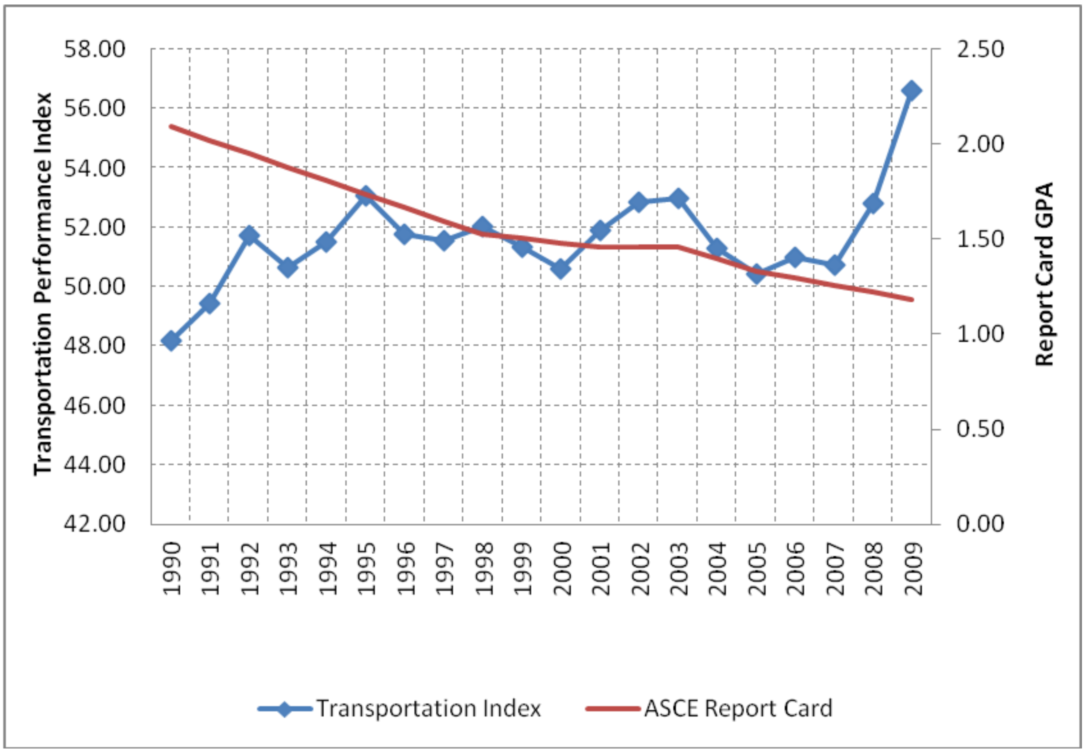


Figure 3 – ASCE Report Card and Transportation Performance Index (1990-2009)

# DATA AND METHODOLOGY

Using both a prospective and retrospective analysis, we explore the impact of various policies and investments on the Transportation Performance Index to better understand and motivate changes in policy. Specifically, the simulation captures the impact of various policies, such as previous legislation, as well as different types and levels of investment on each of the 21 transportation indicators in the 36 metropolitan statistical areas that are used to compute the Transportation Performance Index. Examples of prospective analyses include maintaining a state-of-good repair, and the impact of specific regional plans. Examples of retrospective analyses include the effect of not implementing certain transportation projects that are in the sample MSAs used to compute the TPI.

To explore how the index might change in the future, three scenarios are modelled for 2020 as a part of the prospective analysis. In each scenario, the population of the US is assumed to be growing at 1% per year, which is approximately the annual US population growth rate over the last 20 years (The World Bank Group, 2013). The analysis also assumes that the structure of the economy does not change in the sense that the relative contribution of each MSA does not change. Specifically, the total contribution of each MSA to the US economy measured by GDP remains at 80%, as described in the background. The scenarios are defined as follows:

- Prospective Analysis:
    - Scenario 1 – No New Investment - assumes no new investment. Additional capacity is not added and additional investments in maintenance are not made in response to aging infrastructure.
    - Scenario 2 – State of Good Repair - assumes no new investment other than accomplishing a state of good repair as outlined in the surface transportation funding bill titled Moving Ahead for Progress in the 21$^{st}$ Century Act (MAP-21) and signed into law in July 2012. This scenario assumes the physical condition of transportation infrastructure – roads, bridges, transit, railroads, airports and ports – is upgrading to a satisfactory level but no new capacity is added.
    - Scenario 3 – Significant Investment (State of Good Repair and Congestion Reduction) - assumes significant investment beyond the provisions outlined in MAP-21. These investments not only improve the condition but add capacity.

To explore how the index might have looked, the effects of not implementing nine individual projects are modelled as a part of the retrospective analysis, which is defined as follows:

- Retrospective Analysis:
    - This analysis assumes nine major projects are not implemented. These projects were identified as significant projects from the Transportation Project Impact Case Studies (TPICS) database (Economic Development Research Group, Inc. 2011).

## Prospective Analysis

The specific changes for each indicator for scenarios 1, 2, and 3 are shown in Table 2. Changes are reported as percentage changes or as a specific value for the indicator. In terms of the desired direction for the improvement of an indicator, refer to Table 1. For example, for reserve capacity indicators, the desired direction is a negative percent increase, where they relate to the amount of network capacity that is being utilized for a specific mode. The magnitude of the change is based on the expected change in population, the scenario, and the indicator. For example, highway density (measured as lane miles of highway per 100,000 of population) is computed based on a 1% increase per year in population for scenarios 1 and 2, but there is no change in scenario 3 as investments will keep pace with the growth in population. The new values for the indicators in each scenario are used to calculate projected TPIs, using the procedure outlined in the background section.

The results for the specific changes to TPI are shown in **Error! Reference source not found.**

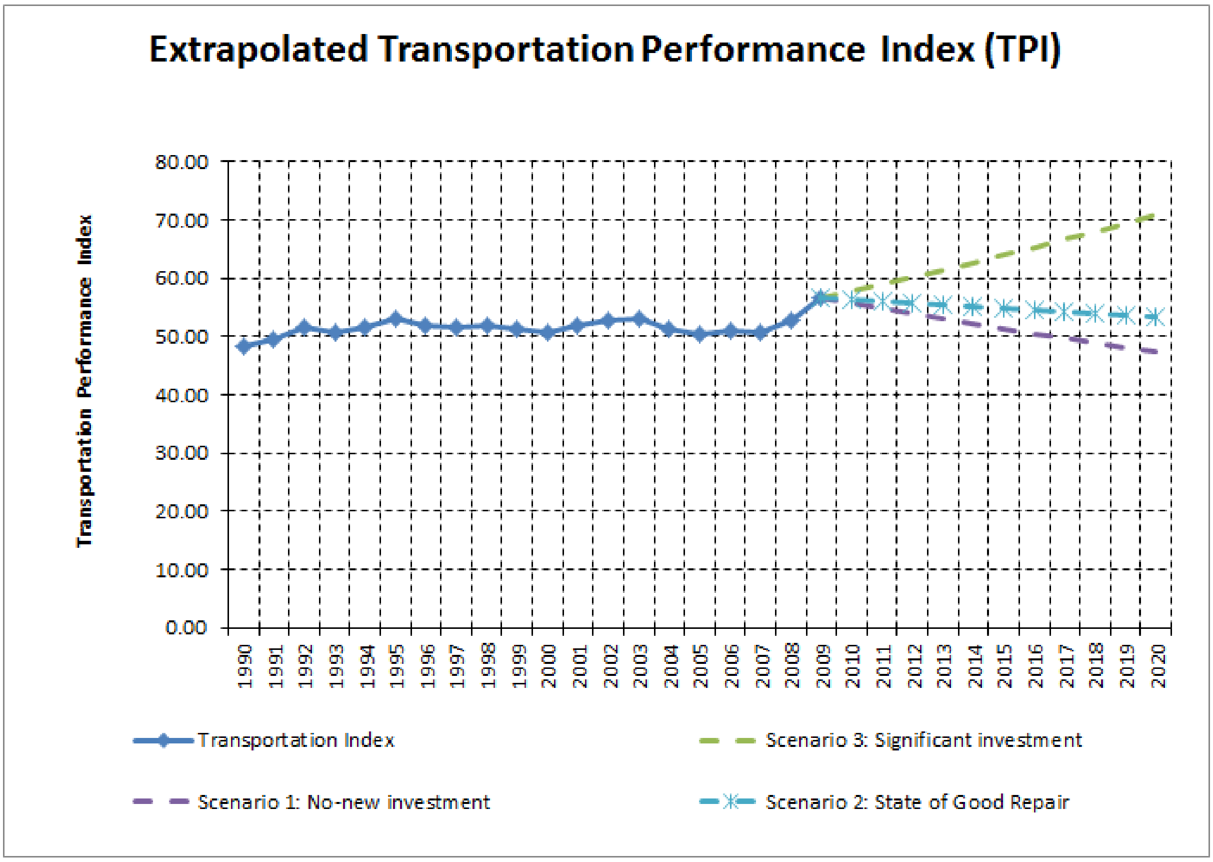


Figure 4.

In general, the results for each of the scenarios are as expected:

- Scenario 1 (no new investment) results in a significant decline in the TPI.
- Scenario 2 (state of good repair) results in a decline in the index to 2008 levels. So while important, state of good repair is just one aspect of transportation infrastructure performance.

- Scenario 3 (significant investment) results in a markedly improved TPI.

Table 2 - Changes in Indicators 2009- 2020 for Three Scenarios

| # | Description | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|
| **IND1** | Highway Density | -10% | -10% | No change |
| **IND2** | Transit Density | -10% | -10% | +15% |
| **IND3** | Airport Access | No change | No change | Indicator=1 |
| **IND4** | Airport Capacity | No change | No change | +15% |
| **IND5** | Rail Density | -10% | -10% | +15% |
| **IND6** | Waterway Density | -10% | -10% | No change |
| **IND7** | Port Access | No change | No change | -15% |
| **IND8** | Intermodal Freight Access | -10% | -10% | +15% |
| **IND9** | Highway Travel Time Reliability | +11% | +11% | -15% |
| **IND10** | Highway Safety | No change | No change | -15% |
| **IND11** | Road Roughness | +11% | Indicator = 0 | -15% |
| **IND12** | Highway Bridge Integrity | +11% | Indicator = 0 | -15% |
| **IND13** | Air Congestion | -10% | -10% | +15% |
| **IND14** | Air Safety | No change | No change | -15% |
| **IND15** | Rail Safety | No change | No change | -15% |
| **IND16** | Waterway Congestion | +11% | +11% | -15% |
| **IND17** | Transit Safety | No change | No change | -15% |
| **IND18** | Highway Reserve capacity | -10% | -10% | +15% |
| **IND19** | Air Reserve capacity | +11% | +11% | -15% |
| **IND20** | Transit Reserve capacity | +11% | +11% | -15% |
| **IND21** | Rail Reserve capacity | +11% | +11% | -15% |

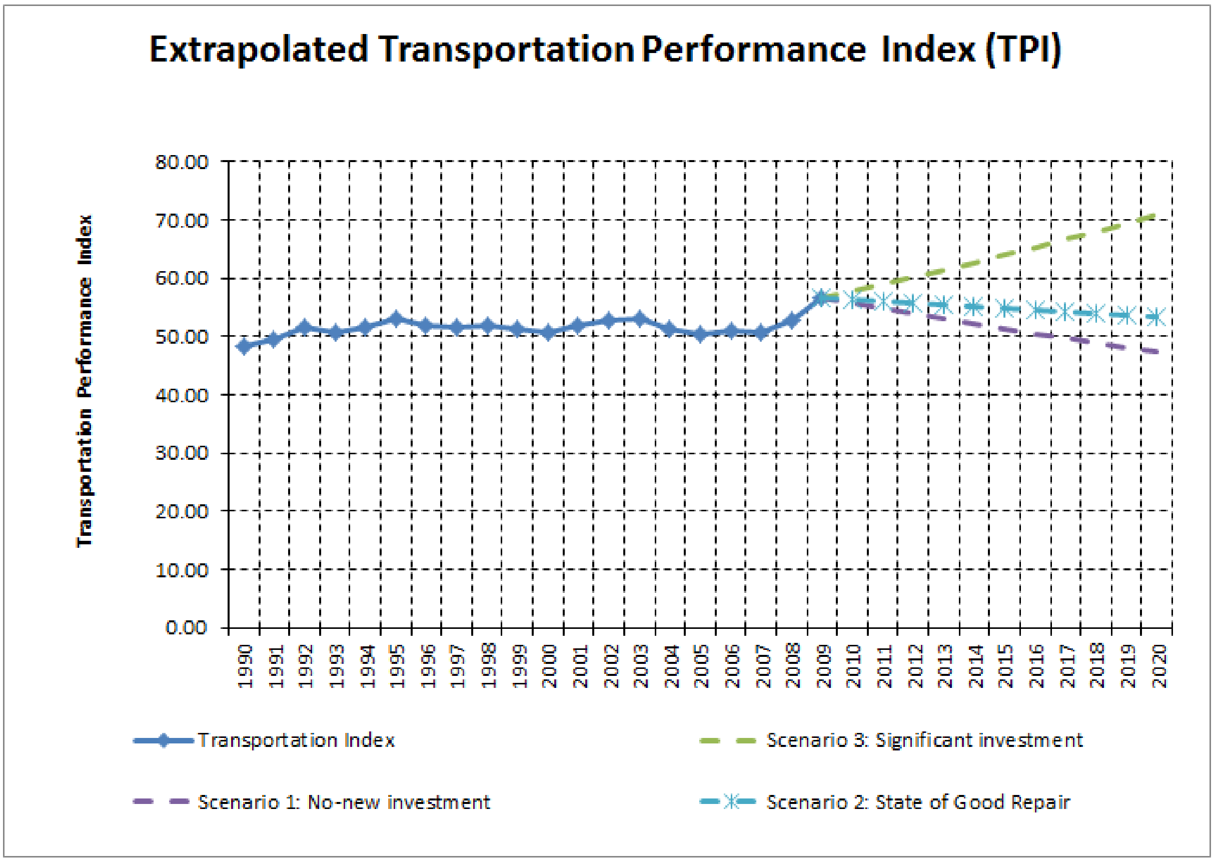


Figure 4 - Extrapolated TPI for Three Prospective Analysis Scenarios

## Retrospective Analysis

For the retrospective analysis, we explore the impact on the TPI of NOT implementing nine significant projects. These projects, which are shown in Table 3, were identified as projects of significance in the sampled MSAs and occurring within the TPI analysis period from 1990 to 2009. These projects include intermodal facilities, transit and highway improvements, as well as reconstruction and congestion relief projects. The projects total $20.8b in constant 2008 dollars and include the Central Artery project in Boston, the largest construction project ever. Each project was reviewed and the impacts on the indicators assessed.

Using the TPICS database, the description and data for each project were reviewed to assist in estimating the change in the TPI indicators beginning in the year in which the project was completed. For three projects (Lindberg Station, MARTA; Anderson Regional Transportation Center; and Dallas High Five Interchange, where the first two projects are multi-modal transit hubs and the last project is an interchange), no indicator captured the changes that occurred. This is consistent with our earlier assessment of the limitations of the TPI (Oswald et al, 2011).

For the other six projects, a change in the value of four specific indicators could be estimated based on the data and descriptions as follows:

- In the case of highway renewal projects (Boston Central Artery Tunnel and I-15 Reconstruction), the projects were assumed to reduce the International Roughness Index (IRI) to a value less than 170 (IND11) and improve the Level of Service (LOS) to C or better (IND18).

- The improvement project for US 75 North Central Expressway is also assumed to improve the LOS to C or better.

- The intermodal terminal project, Fairburn CSX Industry Yard, was assumed to add one intermodal facility to the MSA (IND8) but this was not a significant change to the MSA.

- The Carolina Factory Shops Infrastructure and the DART projects both add route miles (IND1) but these are also insignificant in terms of changes in the MSA.

Table 4 shows the change in the indicators for each project and the year in which the change occurred (based on when the project was completed). For completeness, the three projects with no changes in the indicators are also included in the table. For all other projects only indicators with estimated changes are included, with the insignificant changes in indicators denoted as approximately zero (~0).

The changes to the indicators shown in Table 4 are then used to compute a revised TPI shown in Table 5, assuming the changes in the indicators apply for future years as well as the year in which the project was completed. The renewal and improvement projects are likely to have also resulted in safety improvements but insufficient information was available to estimate the magnitude of these improvements. However, it can be safely assumed that the improvements are not likely to be significant across the MSA. Also, none of these renewal and improvement projects added route miles (IND1). Overall, these assumptions may not be strictly applicable to the entire project or fail to capture other improvements or the changes in the TPI may diminish over time; they mainly serve as an approximation to indicate the magnitude of the changes.

Table 5 also shows the change in the TPI and the cumulative expenditures, based on the assumption that all costs are incurred at the end of the project. The first project to be completed in 1997 did not result in any changes in the TPI and it is not until US 75 North Central Expressway is completed that any changes in the TPI are realized. The data indicates that the changes in the TPI are not significant as the magnitude of the change is smaller than the error in the estimation. However, the cumulative expenditures for these nine projects between 1997 and 2009 are highly correlated (0.87) with the changes in the TPI.

Table 3 - Projects of significance (Source: Based on the TPICS database (Economic Development Research Group, Inc, 2011))

| MSA | Project Name | Description | Actual Cost (2008 $m) |
|---|---|---|---|
| **Atlanta-Sandy Springs-Marietta, GA** | Fairburn CSX Industry Yard (Fairburn, GA) | The Fairburn CSX Intermodal Center was built to create a high volume rail corridor for reliable intermodal service on the lines connecting Southern California ports with Atlanta and with the rest of the southeast region. | $ 206.1 |
| | Lindberg Station, MARTA (Atlanta, GA) | The Lindbergh Station City Center project was planned as a mixed-use transit-oriented development (TOD). Twenty four million dollars were invested by MARTA which included platform additions, stairs, escalators, elevators, concourse areas, fare gates, an upgraded bus transfer system, and a ground-level street plaza. The development around the station included 1 million square feet of office space, 300,000 square feet of retail space, and 714 residential units. | $31.6 |
| **Boston-Cambridge-Quincy, MA-NH** | Central Artery Tunnel (Boston, MA) | The original six-lane highway, built in 1959 on an elevated structure, was plagued by tight turns, an excessive number of exits, entrance ramps without merge lanes, and continually escalating traffic. The Central Artery project was developed in response to these challenges. Construction started in 1991 and by 1995, the Ted Williams Tunnel and the Storrow Drive Connector Bridge were finished. In 2003, the extension of I-90 to Logan Airport via the Ted Williams Tunnel was completed. By 2005, all lanes in the new Central Artery Tunnel were opened to traffic. | $17,712.5 |
| | Anderson Regional Transportation Center (Woburn, MA) | The Anderson Regional Transportation Center (ARTC) is a multi-modal transit hub with commuter rail and bus service to Boston and points north. The project involved cleanup of a superfund site, and construction of the intermodal facility, new surface roads and a highway interchange. | $73.7 |

| MSA | Project Name | Description | Actual Cost (2008 $m) |
|---|---|---|---|
| **Charlotte-Gastonia-Concord, NC-SC** | Carolina Factory Shops Infrastructure | Construction of water system and access roads to serve the Carolina Factory Shops site. The project included 3 phases and grew 400,000 sq ft & 800 jobs by 1998. | $1.4 |
| **Dallas-Fort Worth-Arlington, TX** | Dallas High Five Interchange (Dallas, TX) | The Dallas High Five Interchange is a reconstruction of an existing three-level interchange at the intersection of Interstate 635 and U.S. 75 in Dallas, Texas. The project involved extensive reconstruction of an existing loop interchange to complement other planned transportation improvements in the area, including improvements to the I-635 and US 75 corridors. | $305.4 |
| | US 75 North Central Expressway, (Dallas, TX) | TxDOT, DART, and the Cities of Dallas, University Park and Highland Park entered into a partnership to reconstruct a 9-mile segment of US 75 to eliminate short sight lines, redesign on-ramps and acceleration lanes, and add capacity. The highway now has a minimum of eight continuous general purpose lanes and is in a trench for six of the nine miles between downtown and I-635 (the LBJ Freeway). | $428.5 |
| | DART | The LBJ-Skillman is on DART's light rail system on the Blue Line. The project included vehicle access ramps, new roadway infrastructure, the widening of the Miller Road bridge, and a new frontage road. However, the planned TOD here has not yet been developed. | $103.8 |
| **Salt Lake City, UT** | I-15 Reconstruction (Salt Lake City, UT) | The I-15 Reconstruction Project involved the rebuilding and widening of a deteriorated, congested 17 mile stretch of Interstate 15, running through Salt Lake City. The project was necessary to accommodate the rapid growth the region was experiencing, much of which was due to in-migration from California. | $ 1,964.3 |

Table 4 - Change in indicators if projects were not implemented

| Project | Year Completed | IND1 | IND8 | IND11 | IND18 |
|---|---|---|---|---|---|
| **Fairburn CSX Industry Yard, (Fairburn, GA)** | 1999 | | ~0 | | |
| **Lindberg Station, MARTA (Atlanta, GA)** | 2004 | No Changes to TPI Indicators | | | |
| **Central Artery Tunnel (Boston, MA)** | 2006 | | | 4.43 | -4.43 |
| **Anderson Regional Transportation Center (Woburn, MA)** | 2001 | No Changes to TPI Indicators | | | |
| **Carolina Factory Shops Infrastructure** | 1997 | ~0 | | | |
| **Dallas High Five Interchange (Dallas, TX)** | 2005 | No Changes to TPI Indicators | | | |
| **US 75 North Central Expressway (Dallas, TX)** | 1999 | | | | -2.82 |
| **DART** | 2002 | ~0 | | | |
| **I-15 Reconstruction (Salt Lake City, UT)** | 2001 | | | 31.59 | -31.59 |

Table 5 Impact on TPI if projects were not implemented

| Year | Transportation Performance Index w/o projects | Transportation Performance Index w/ projects | Overall Change in TPI due to Projects (%) | Cumulative Expenditure on Significant Projects ($m) |
|---|---|---|---|---|
| **1990** | 48.17 | 48.17 | No change | No investment |
| **1991** | 49.42 | 49.42 | No change | No investment |
| **1992** | 51.73 | 51.73 | No change | No investment |
| **1993** | 50.65 | 50.65 | No change | No investment |
| **1994** | 51.50 | 51.50 | No change | No investment |
| **1995** | 53.07 | 53.07 | No change | No investment |
| **1996** | 51.75 | 51.75 | No change | No investment |
| **1997** | 51.55 | 51.55 | 0 | 1.4 |
| **1998** | 52.02 | 52.02 | 0 | 1.4 |
| **1999** | 51.31 | 51.36 | +0.05 | 636.0 |
| **2000** | 50.58 | 50.62 | +0.04 | 636.0 |
| **2001** | 51.76 | 51.90 | +0.14 | 2674.0 |
| **2002** | 52.71 | 52.85 | +0.14 | 2777.8 |
| **2003** | 52.94 | 52.99 | +0.05 | 2777.8 |
| **2004** | 51.17 | 51.30 | +0.13 | 2809.4 |
| **2005** | 50.28 | 50.42 | +0.14 | 3114.8 |
| **2006** | 50.78 | 50.99 | +0.21 | 20827.4 |
| **2007** | 50.52 | 50.74 | +0.22 | 20827.4 |
| **2008** | 52.60 | 52.82 | +0.22 | 20827.4 |
| **2009** | 56.37 | 56.60 | +0.23 | 20827.4 |

# RESULTS/FINDINGS

While several studies demonstrate the important connections between transportation policy and economic growth, we do not have a clear understanding of the causal relationship between infrastructure and the economy, and more importantly what it takes to improve infrastructure performance. This analysis provides some insight into the relationships between infrastructure performance and specific projects and policies.

First, from the prospective analysis using different investment policy scenarios, it is shown that increased investment is essential in improving the performance of our transportation infrastructure. However, the key is the level of investment that is pledged and whether it's towards supply, quality of service or utilization for transportation services. The analysis demonstrated that the TPI can capture changes in investment, changes in demand (due to population growth) and alternative policies such as maintaining the status quo (scenario 1) versus focusing on state of good repair (scenario 2).

Second, from the retrospective analysis using specific projects, the analysis demonstrates the magnitude and timing of specific projects. The results showed that an investment of almost $(US) 23 billion in nine projects changed the TPI by only 0.23%. The analysis also demonstrates the importance of network effects, comprehensive and coherent planning, and the limited impact of isolated regional investments on national infrastructure performance. In addition, it further supports the idea that not one project, investment in a single region or a single mode, will significantly change the value of the TPI, where a system or network approach is needed to create considerable change in transportation performance.

Identifying both specific projects and policies to improve infrastructure performance is challenging. This is further evidenced by the generic nature of the key solutions proposed by ASCE that include (ASCE, 2012):

- Increase Federal Leadership in Infrastructure
- Promote Sustainability and Resilience
- Develop Federal, Regional, and State Infrastructure Plans
- Address Life-Cycle Costs and Ongoing Maintenance
- Increase and Improve Infrastructure Investment from All Stakeholders

Working with the data and information that are used to develop the TPI, the following portfolio of strategies for improving infrastructure performance was developed:

- Wise investments in  all modes and connectivity between the modes
- Responsible stewardship of existing infrastructure

- Recognition of the life costs of infrastructure investment and the commitment to the cost of owning, using and operating infrastructure
- Innovative operating and maintenance practices
- Willingness to pay for a world class infrastructure.

Implementing any of these strategies also requires us to understand who is going to pay, when are we going to pay (assuming we do not want to transfer the cost to future generations), and what tradeoffs are we making (including environmental costs). These are clearly difficult decisions.

Another set of strategies focus on innovation to improve operations and the performance of our transportation infrastructure. Over the past three decades many innovative technologies, practices, materials and processes have been deployed to improve the performance of our transportation infrastructure. Examples include:

- ITS technology
    - Improved operations (response to non-recurring congestion, information to support distribution of recurring congestion over longer peak)
    - Improved passenger information for transit
    - Streamlined methods for paying for transportation such as EZ-Pass and SmartCards
- RFID technology to help speed up inventory/ delivery (Fedex and UPS has some great examples) – also container management
- Improved maintenance and renewal of existing infrastructure using asset management and preservation strategies.
- Improved vehicle technology to improve safety (ABS, airbags, stability control)
- Anti icing
- Better pavement designs (last longer, need less repair)
- Transit check (paying for commuting costs in pre-tax dollars)
- Real time information to support 3rd party logistics companies make better decisions
- Positive train control
- Continuously welded rail/ advances in rolling/ grinding/ lubricating rail
- Retroreflective materials
- Alternative fuels

- Nighttime maintenance (reduces non-recurring congestion)
- Innovative repair strategies, and
- HOT lanes

Many of these innovations have played an important role in maintaining the overall performance of our transportation infrastructure. The challenge is to develop policies to support continued innovation and opportunities to systemically and comprehensively support actions to enhance infrastructure performance.

# IMPLICATIONS FOR RESEARCH/POLICY

Specific recommendations for supporting improved infrastructure performance include:

1. Create incentives to increase innovations in configuration, operations, and intermodal connections.
2. Create a coherent national transportation policy that recognizes tradeoffs between modes and performance measures.
3. Link funding to performance
4. Support more research to generate innovation and new ideas
5. Streamline the project delivery process
6. Create incentives for improving network performance

With constrained budgets, growing recognition of the broader implications of transportation investment on the economy and environment, and aging infrastructure, the need for high level policy tools is growing. However, such tools need to be used in the appropriate context to provide guidance on specific aspects of policy. This work and the TPI serve as a foundation for future research to help support more sophisticated tool development, and as a policy analysis tool, assist with the evaluation of policy alternatives.

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