



PRODUCTIVITY AND THE HIGHWAY NETWORK:

A Look at the Economic Benefits to Industry
from Investment in the Highway Network



U.S. Department
of Transportation
**Federal Highway
Administration**



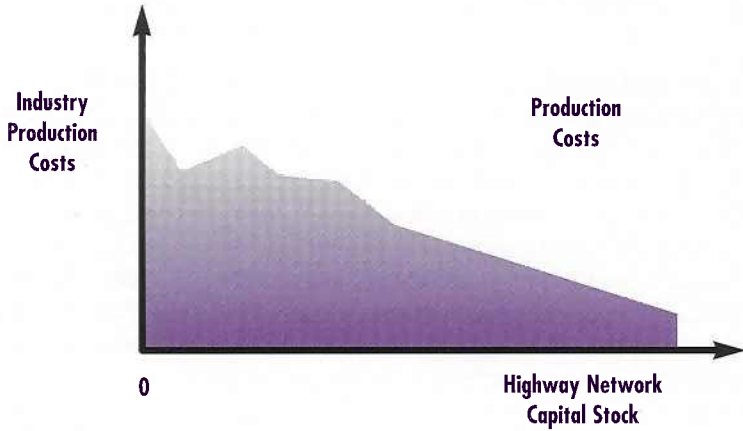
Summary of Results

Productivity and the Highway Network

A new study establishes a strong link between the highway network and national economic performance. Unique in the depth and breadth of its 35-industry analysis, this research sheds new light on the commercial benefits of highway infrastructure investments. The Federal Highway Administration (FHWA) is pleased to present this research because it clearly documents the highway network's contribution to industry productivity growth, national economic performance, and international competitiveness. Although a comprehensive assessment of the social costs and benefits of the road system is beyond the scope of this research and would include a wide range of factors, such as the impacts on consumers as well as producers, employment effects of highway construction projects, and environmental and social effects of highway provision and use, this work provides important empirical evidence about the historic contribution of roads to the U.S. economy. Key findings include the following:

- **Over the period 1950 to 1989, U.S. industries realized production cost savings averaging 18 cents annually for each dollar invested in the road system.** This is an average result for the U.S. highway system as a whole over the 40-year period, which highlights the positive role of highway investment in fostering economic growth. Investments in non-local roads, a subset of the entire network, yield even higher production cost savings, estimated at 24 cents for each dollar of investment. These results reflect the important contributions of an expanding highway network to the rapid growth of the U.S. economy during the late 1950's and 1960's. Although the impact of highway investment on productivity has declined coincident with the decline in national productivity growth since the early 1970's, results suggest that highway infrastructure investments more than pay for themselves in terms of industry cost savings.

- **The highway network's contribution to economic productivity growth was quite large during and immediately following the interstate construction era. Although the impact has declined considerably since the 1970's, highway investment remains an important contributor to economic productivity growth.** During the period 1980 to 1989, highway capital investments contributed between 7 and 8 percent to annual productivity growth. The implication is that strategic highway investments, timely maintenance, and further progress in the deployment of advanced technology will continue to make a positive and significant contribution to national productivity growth and economic development.



- **The net social rate of return on investment in the non-local road system during the 1980's was 16 percent, and the rate of return for the entire road network was 10 percent.** Net social rate of return is an estimate of benefits to private industries derived from the shared use of public highways. The rate of return calculated for the non-local road network in the 1980's was significantly higher than the prevailing rate of return on private capital and the long-term interest rate. The higher return to highway capital is due to its network feature, i.e., its benefits are shared by all industries. These results show that the non-local road system provides a highly competitive return on funds invested.

I. Economic Benefits of the Highway Network

The highway network provides important economic benefits to individuals and businesses throughout the United States. Improved reliability, quality, and access of the highway network promote efficiency through industrial restructuring, adoption of new transport technologies, cost reductions, and changes in distribution or logistics patterns. Thus, a well-functioning highway network helps the Nation maintain a globally competitive position.

There are three general categories of economic benefits from the highway network. The first category includes employment supported by highway construction activities (see companion brochure, *The Employment Benefits of Highway Investment*). The second category encompasses direct user benefits accruing to commuters and travelers, including time savings, safety improvements, and vehicle operating cost reductions. The third category covers industry productivity. Transportation investment promotes efficiency through adoption of new transport technologies, expanded intermodal access, and reduced costs. This brochure focuses on measuring industrial productivity effects. Information on industrial productivity benefits is useful to the FHWA as the agency evaluates Federal-aid program investments, promotes public-private joint ventures, and reports the conditions and performance of the U.S. highway system.

Traditionally, highway investment decisions have been based on direct user benefits of reduced operating costs, travel time, and accident rates. Economic development objectives have often played a role in investment decisions, but the impact on industry productivity has seldom been considered. *Productivity* is the ratio of outputs produced to the inputs used to produce those goods and services. Productivity growth occurs when the same inputs produce more output. This growth may be caused by higher education and skill levels, growth in the quality and quantity of the capital stock, innovation, technological advances, or public investment, such as highway investment.

It is clear that public investments to increase the economic impact of the highway network result in important monetary benefits for the private sector. These commercial benefits of the highway network improve the standard of living throughout the United States by reducing the costs of production, supporting productivity and output growth, and promoting international competitiveness.

A new study by M. Ishaq Nadiri of New York University and the National Bureau of Economic Research and Theofanis Mamuneas of New York University estimates industry productivity benefits resulting from the highway



network. This study was sponsored by the FHWA and reviewed by a panel of expert economists. This research is unique in the depth and breadth of its 35-industry data base and its ability to present new measures of industry productivity benefits. It supports the premise that the highway network positively influences economic performance.

Economic tools linking the highway network to economic performance provide important insights for:

- formulating national transportation policy,
- understanding the relationships between public capital investments and private-sector behavior; and
- promoting national economic growth and international competitiveness.

II. A New Approach to Measuring the Contribution of the Highway Network

The recently completed research by Nadiri and Mamuneas provides estimates of the economic benefits of: (a) *the entire highway network* and (b) *the non-local road system*. **This FHWA work-in-progress provides industry and national estimates of the impact of the highway network on U.S. production costs.** Uniquely, this effort estimates the benefits that accrue individually to 35 industries from highway investment. The industry data base includes agriculture, mining, manufacturing, and services. The industry benefits are summed to the national level, providing a rich understanding of the interrelationships between the publicly provided highway network and private sector economic performance.

The highway network measure used in this study is the net highway “capital stock,” referred to here as the highway network. Highway capital stock is the accumulation of all past net investment by Federal, State, and local governments, adjusted for depreciation. Three main categories of highway investment are covered in this measure of the highway network: paving, grading, and structures. The average lives for roadway paving, grading, and structures are assumed to be 14, 80, and 50 years, respectively. The highway capital stock measure is based on a 1986 effort, “Public Infrastructure Data Development” by Randy Eberts, Chul Park, and Douglas Dalenberg for the National Science Foundation. Like private capital, this public capital—the highway network—is used in combination with other assets and/or inputs to produce output.

The researchers use an econometric cost modeling approach to estimate the impact of the highway network on industry costs. Improved highway reliability and access allow industries to restructure, thereby reducing their costs of production or service provision. A well-functioning highway system allows businesses to hold less inventory, use just-in-time inventory procedures, enjoy greater locational choice, and change distribution or production patterns in other ways. Reduced transportation costs can also generate savings in the overall cost of production.

Cost = function of : the price of inputs such as labor, materials, and private capital; the level of gross output; and the highway network



A firm's cost of production is a combination of the input prices (e.g., wages and the cost of capital) and quantities of output (see box on previous page). In the approach presented in this research, private industry costs are influenced by the highway network. This methodology provides a measurement of the highway network's effect on output, total costs, and other factors of production, such as employment and private capital.

Average *production cost savings* have been estimated for the period 1950 to 1989 for all industries. This estimate indicates that for a \$1-million increase in the stock of the highway network, all industries combined would experience an average production cost savings totaling \$180,000 per year. The model is re-estimated using the smaller subset of highway capital—that is, non-local roads. The researchers find that the production cost savings is significantly higher for interstate and interregional routes. Indeed, the annual cost savings to industry of the non-local road system is 24 cents for each \$1 increase in the non-local road network during the period 1950 to 1989. This reinforces the positive role of connectivity and higher level roads in generating commercial economic benefits.

The second measure, *contribution to productivity growth*, suggests how important the highway network has been to overall growth in technological change and innovation from 1950 to 1989. The time profile for this relationship shows that in the 1950's, the highway network's contribution to the annual productivity growth rate was 31 percent, in the 1960's it was 25 percent, in the 1970's it was 23 percent, and by the 1980's it was 7 percent, still a positive overall contribution. For the non-local road network, this time profile is similar, but the magnitudes are slightly higher. This result, in combination with others from the study, leads the researchers to conclude that the

highway network contributes significantly to the average productivity growth rate. But the highway network's contribution has normalized over time.

The third measure, *net social rate of return*, is an estimate of the net benefits to private industries that share use of the public highway or non-local road network. The term "social" refers to the fact that the highway network is a shared investment used by all industries in the economy. This research indicates that net social rate of return for the highway network in the 1950's and 1960's was about 35 percent. This period coincides with the Interstate expansion era, when quantum expansion in accessibility was being provided. As the highway network expanded, the very high social rate of return began to normalize. The net social rate of return for non-local roads in the 1980's was 16 percent. The net social rate of return to the entire highway network has declined to 10 percent in 1989, which is comparable with the prevailing rate of return on private capital and the long-term interest rate.

This study by Nadiri and Mamuneas suggests the key findings that the highway network: (1) leads to production cost savings, (2) contributes to productivity growth, and (3) has a positive net social rate of return. The results show that historically the highway network, as well as the non-local road system, has provided a significant return on public investment.

III. Important to Note

Nadiri and Mamuneas have attempted to account for the most frequent criticisms of past research that estimated the impact of the highway network or the larger category of public capital on productivity. The research was undertaken with the benefit of a review panel comprising numerous expert economists. Three issues merit awareness. First, the research reflects various assumptions, such as rates of depreciation used in calculating an estimate of highway network capital. If these assumptions are altered, the rate of return estimates may be affected. Second, the model estimates include only one measure of public infrastructure capital, highway capital. The researchers are aware that the exclusion of other public capital from the model could influence the magnitude of the highway network's impact on economic benefits. However, experts believe that if the highway network and other public capital both increase at the same time, the impact of highway infrastructure on productivity may actually be underestimated. Third, these results reflect a combination of results from 35 separate industries. Impacts on specific industries do vary significantly. Industry-level results are not presented here, because additional research is required to verify industry-specific estimates.



IV. Summary

This research indicates that highway infrastructure matters in ways decision-makers may not have emphasized in recent years. Previous transportation decisions focused primarily on the benefits of mobility and accessibility for all citizens and the employment benefits of the highway system. This research indicates that there are considerable economic benefits that accrue to industry from key highway network features. Clearly, investments that improve access, reliability, and intermodal connectivity have a positive economic impact. Such investments reduce the cost of production and promote output and productivity growth, increase U.S. industry's ability to compete globally, and enhance our U.S. standard of living. It should be noted that this research presents information on one type of economic benefit from the highway network, that is, industry productivity impacts. To assess the total benefits to society of the highway network, measures of direct user benefits, and environmental and social impacts, among others, are also required. The first steps have been taken, but continued research efforts are necessary to achieve a deeper understanding of the importance of the transportation network to the economic viability of the United States in the 21st century.

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