The Contribution of Highways to GDP Growth[1]

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Introduction

This research represents the next step in advancing our understanding of the contribution of highways to economic growth. In a previous research, Fraumeni constructed improved measures of highway capital stock (Fraumeni, 1999). As a result of this research and a paper by Beemiller (1999), the Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce revised its highway lifetimes substantially downward from 60 to 45 years (Fraumeni & Bennet, 1999) as part of its 1999 comprehensive revision of the national accounts.[2] This change had a small, but measurable, affect on the official measure of Gross Domestic Product (GDP), which BEA produces.[3] The Fraumeni highway capital stock estimates are also publicly available for use in economic research and policy analysis.

The current research has four objectives directly related to measures of productive highway capital stock. First, it updates and extends the productive capital stock measures. Second, it addresses two important questions related to the stock measures: Have the parameters underlying the estimates changed significantly in the most recent period and what is the value-added of the Fraumeni measures compared to the BEA measures? The pavement curves are the focus of the parameter question. As BEA modified its asset lifetime measures during its 1999 comprehensive revision of the national accounts, perhaps the BEA stock estimates suffice? Third, it examines in a pilot study whether the highway structure stocks could be improved with growth rates from a quality-adjusted bridge measure. Fourth, it has the goal of making updating the productive stock measures a routine matter, producing detailed "cookbooks" that document how to update the research source files. Each of these objectives contributes to the value of the overall research.

The entirely new element in this research is the measurement of the contribution of highways to economic growth. From the perspective of national income accounting, there are three types of contribution: 1) The contribution of highway investment (capital outlays) to growth in GDP, 2) The contribution of highway capital input to growth in adjusted GDP, and 3) The contribution of highway gross output to growth in adjusted U.S. gross output. The data effort moves beyond productive capital stocks to assess the contribution of highways to economic growth; measures of capital input (which require rates of return), highway "industry" gross output, and U.S. gross output are needed. These contribution estimates provide a different perspective on the importance of highways for economic growth from those produced using different methodologies, which commonly employ econometric techniques.[4]

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[2] In this paper, the term "highways" refers to both highways and streets. The Bureau of Economic Analysis refers specifically to highways and streets.

[3] The increase in consumption of fixed capital, a component of GDP, was less than 1% of total U.S. consumption of fixed capital (Fraumeni and Bennet, 1999).

[4] For an example of estimates produced using an econometric model, see Nadiri and Mamaneus (1996).

The study reaches two conclusions using several different national income accounting measures:

- The rate of growth of highways is below the rate of growth of Gross Domestic Product (GDP), and
- The nominal share of highways in (adjusted) GDP and (adjusted) U.S. gross output is small.

National income accounting measures do not include spillovers, multiplier effects, or the use of highways by other than business or the government. Accordingly, the contribution estimates produced in the research are small compared to many alternative estimates. However, they can be directly compared to Bureau of Economic Analysis (BEA) contribution estimates.

This is the first time the contribution of highways to economic growth has been estimated using this method. In a report released in January of 1999 Fraumeni estimated productive highway capital stocks from 1929-1995.[5] The current study presents revised and updated the productive highway capital stocks through 2005 and estimated the contribution of highways to economic growth.

The study presents two conclusions about the revised and updated productive highway capital stocks:

- The pavement curve parameters have not changed significantly in recent years, and
- The Fraumeni productive capital stock estimates are preferred to those of BEA because the detailed break-outs capture the changing composition of highways outlays.

An experimental bridge stock is estimated. It results in a small, although significant, difference in the rate of growth of the productive highway structure capital stock.

Besides this paper, two volumes describe the research.[6]

Productive Highway Capital Stock Estimates

The productive highway capital stocks measure potential productive capacity. There is no stock utilization adjustment except in construction of pavement curves. (Utilization and other factors might affect the rate of return to the stock.)

Highway capital outlays are disaggregated into:

- Interstate System
- Non-interstate State System
- Local System

by

[5] Fraumeni, January1999.

[6] Fraumeni, Volume I and Volume II, October 2007. Volume II is a "cookbook" which describes in detail how the stock and contribution estimates are constructed. A five page summary of Volume I will be posted on the Federal Highway Administration web site (Fraumeni, forthcoming).

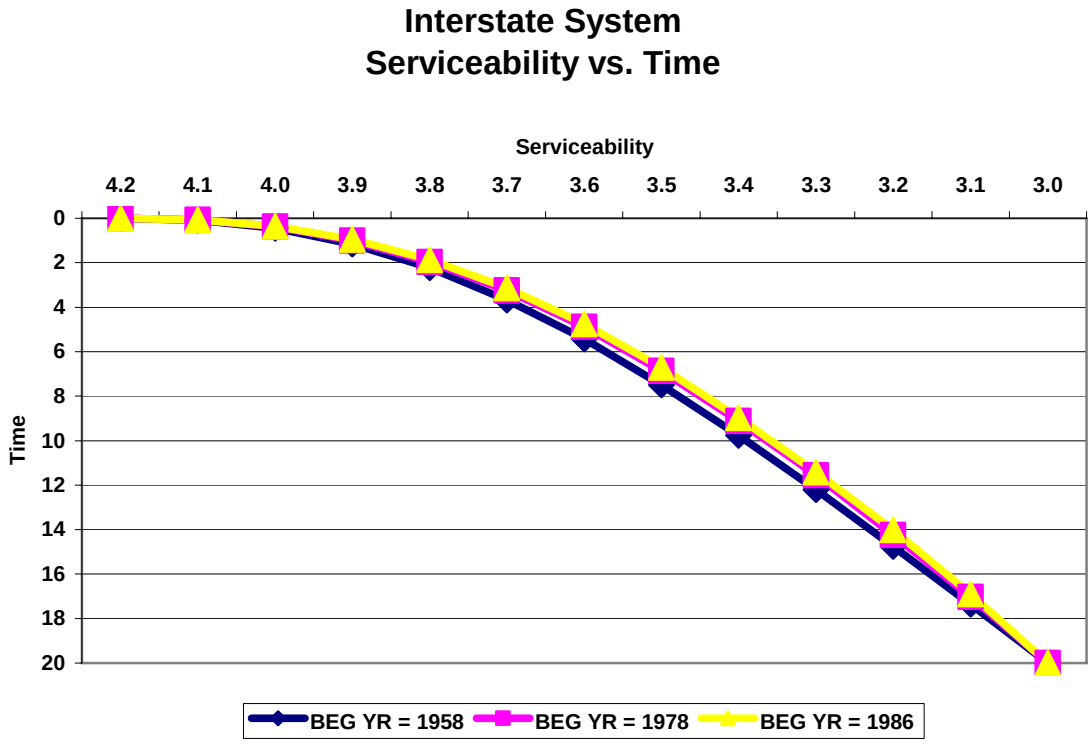
- Right-of Way (ROW)
- New construction or reconstruction
- Other than new construction or reconstruction

and by

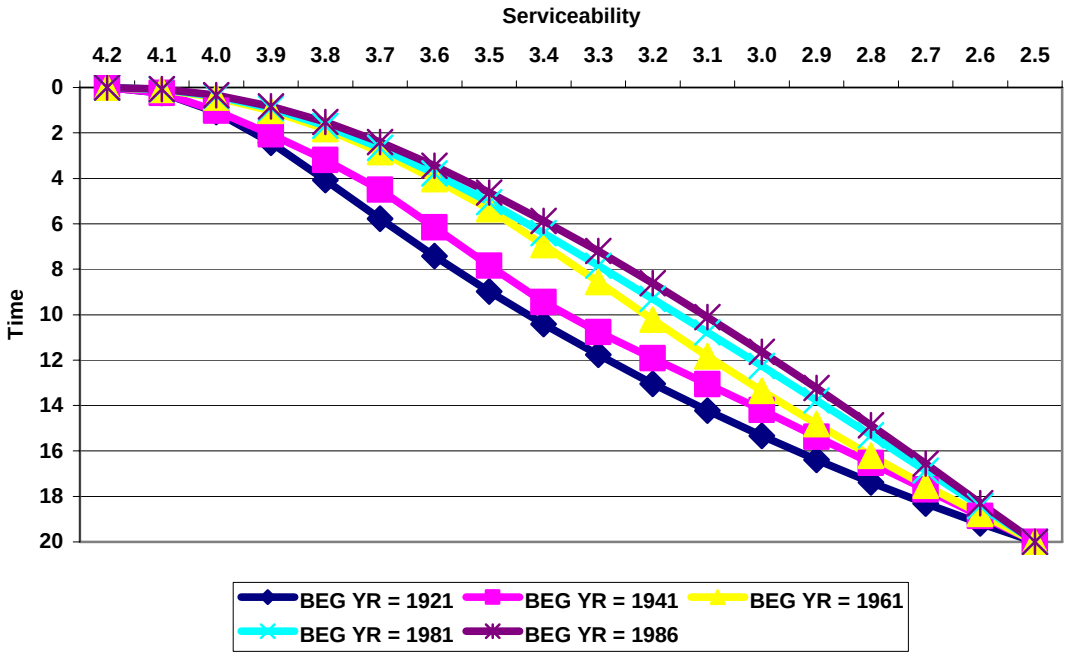
- Pavement
- Grading
- Structures.

The split of outlays differs year-by-year reflecting changes in how capital outlays are spent.

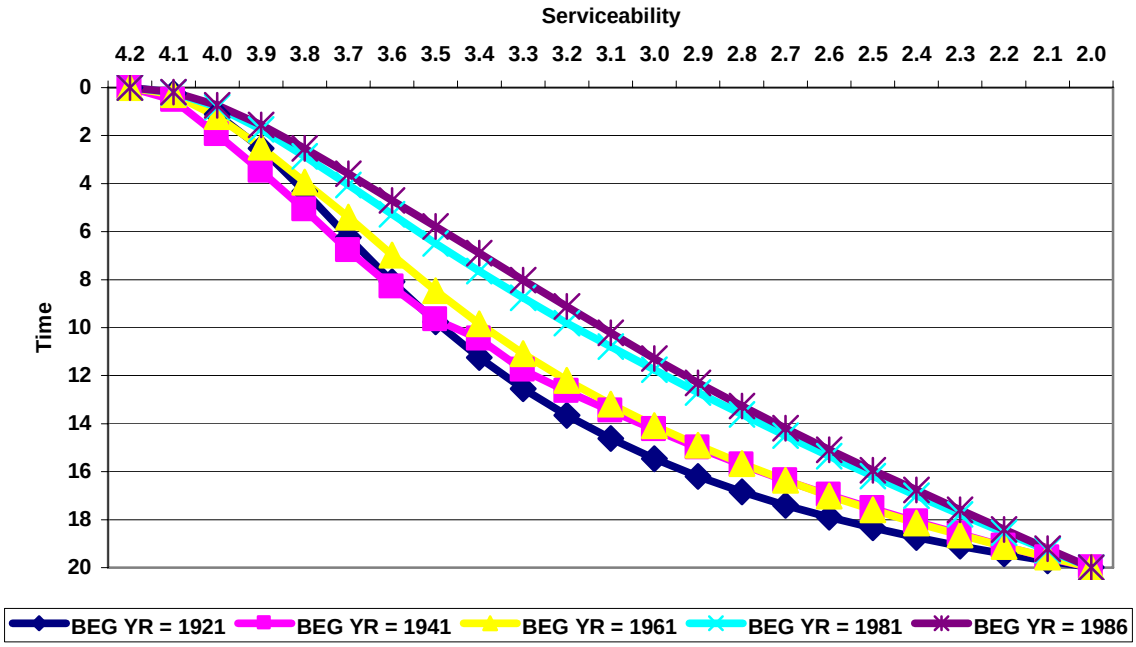
Net efficiency pavement curves, constructed from pavement curves, measure how productive pavements could be. The estimation of net efficiency curves begins with the construction of a pavement serviceability – time relationship based on the intensity and type of traffic, and the road system: Interstate, Non-Interstate State, or Local System. Pavement serviceability determines the pavement condition. At the end of the 20-year design life, the Present Serviceability Index (PSI) is assumed to be 3.0 for the Interstate System, 2.5 for the Non-Interstate System, and 2.0 for the Local System. Serviceability curves for the Interstate System are constructed for years beginning in 1958, 1978, and 1986; for the Non-interstate and Local Systems for 1921, 1941, 1961, 1981, and 1986. The curvature of the Interstate System curves are convex throughout; the curvature switches from convex to concave in the early years in two of the Non-interstate State System curves, and in all of the Local System curves. For all systems, there is very little difference between the curves beginning in 1978 or 1981 and those beginning in 1986. The following graphs show the serviceability vs. time curves for each of the three systems.



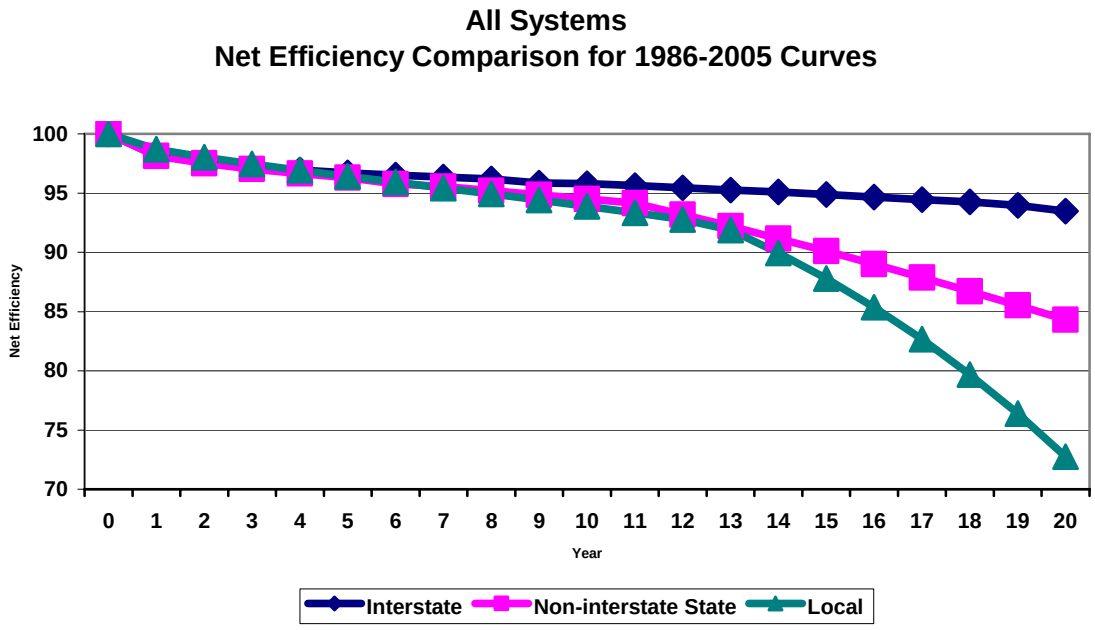
Non-interstate State System
Serviceability vs. Time



Local System
Serviceability vs. Time



Net efficiency, which is the basis for productive capacity, is reduced if pavement conditions reduce speed or increase motor vehicle operating cost. Pavement net efficiency on average never gets below 93% for the Interstate System curves; 84% for the Non-interstate System curves; and 72% for the Local System curves. The following graph shows the 1986-2005 net efficiency curves by system.



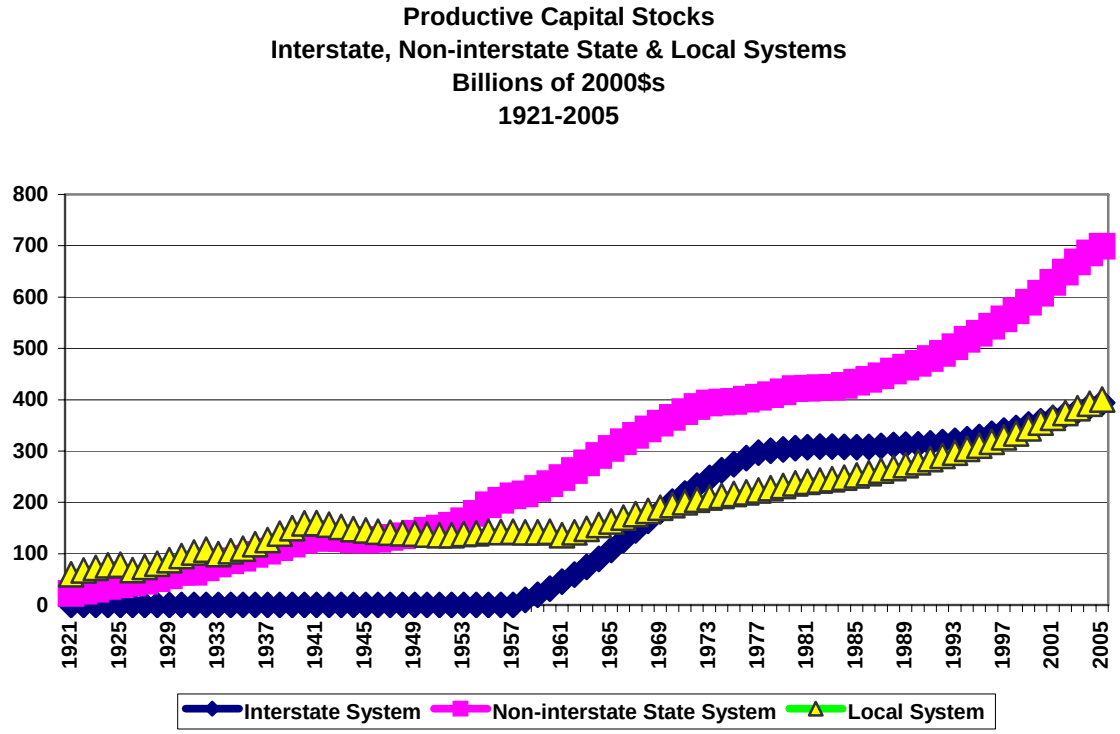
The research constructed productive highway capital stocks with a perpetual inventory method. State and Local Systems have a 1921 benchmark. Interstates have a 1958 benchmark from highways transferred from the State System. ROW has an infinite life; therefore zero depreciation. Pavement has a design life of 20 years and depreciation from the net efficiency curves. Grading has an 80-year life and one-hoss-shay depreciation. Structures have a life of 50 years and a geometric depreciation rate of 1.82 percent. (The structure assumptions are the BEA's assumptions for government non-defense, non-industrial buildings.)

Information on all rated bridges from the 1983, 1996, and 2006 National Bridge Inventory (NBI) is used to construct an experimental quality-adjusted bridge stock. This stock is equal to the summation across all bridges of their length times the number of lanes times the inventory rating.[7] Under the simplifying assumption that all highway structures are bridges, implementation of the quality-adjusted experimental bridge would increase the annual rate of growth of the highway structure series by about four-tenths of

[7] There are between 464,000 and 472,000 rated bridges in each of the included years. The National Bridge Inventory coding text describes inventory rating as "The capacity rating, for which the vehicle type used in the rating, will result in a load level which can safely utilize an existing structure for an indefinite period of time." See U.S. Department of Transportation, FHWA (January 1979) p. 31.

a percentage point from 1983-1996 and by about two-tenths of a percentage point from 1996-2006.[8]

The following graphs the productive highway capital stocks for the Interstate, Non-interstate State, and Local Systems. By 2005, in 2000 dollars the total stock is close to $1.5 trillion.



Contributions

The research estimates three types of contributions:

- Contribution of highway capital outlays to GDP growth (1929-2005)
- Contribution of highway capital input to adjusted GDP growth (1929-2005), and
- Contribution of highway gross output to adjusted U.S. gross output growth (1958-2005).

Each of these contributions is an approximate contribution.

Approximate contributions in this research are estimated as a weighted rate of growth. The weights are nominal shares of:

- Highway capital outlays in GDP
- Highway capital input in adjusted GDP or
- Highway gross output in adjusted U.S. gross output.

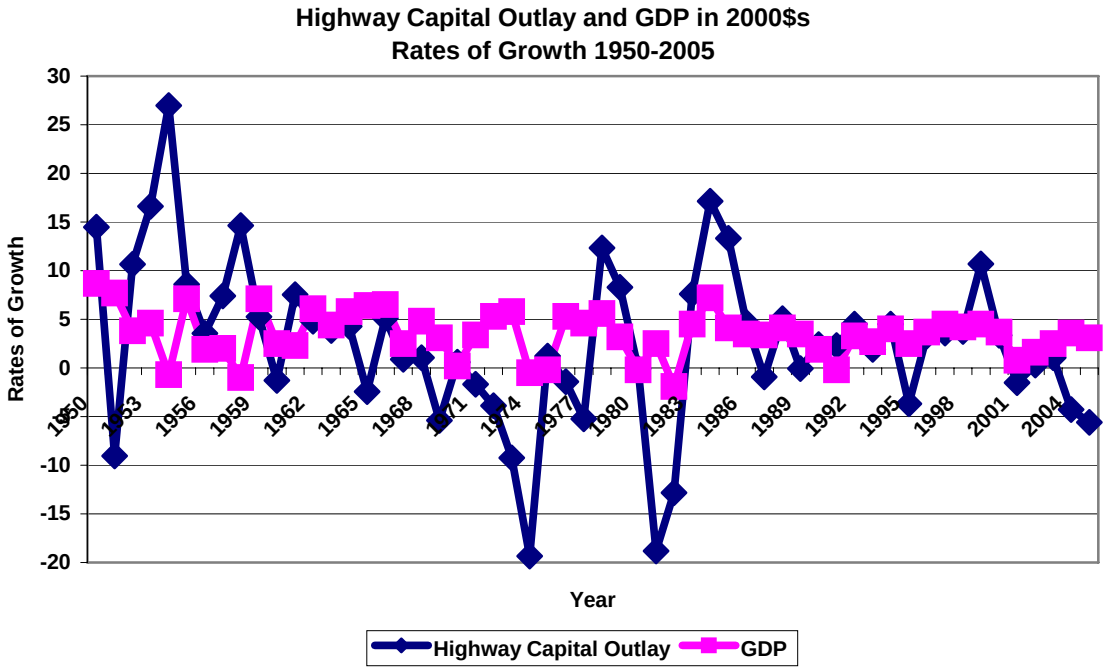
The rates of growth are rates of growth of 2000 dollars for:

[8] The difference for the latter period is an approximation as the base case highway structure series ends in 2005.

- Highway capital outlays
- Highway capital stock or
- Highway gross output.

The first listed weight is multiplied times the first listed rate of growth to produce the first listed contribution; the second listed for the second, and so forth. In the majority of years, the weights and the rates of growth are small; accordingly the contributions are small.

Highway capital outlays in 2000 dollars are highly variable and their rate of growth is less than the rate of growth of GDP. The following graph begins in 1950 as in some earlier years the rate of growth of highways capital outlays are almost 70 percent and –90 percent, swings that hide more normal variations.



Over the period shown the average annual rate of growth of highways capital (2000 dollars) outlays is 2.5 percent and the annual rate of growth of GDP is 3.5 percent.

Nominal capital input is set equal to the sum of net return and depreciation. Net return is equal to the net own rate of return times lagged capital stock. For highways, net own rate of returns for all government (4.4 percent) and all private assets (11 percent) are derived from BEA's recent report on R&D.[9] The study estimates three rate of return scenarios:

- The government net own rate of return is used for all highway systems
- The private net own rate of return is used for the Interstate System; the government net own rate of return is used for all other systems and
- The private net own rate of return is used for all systems.

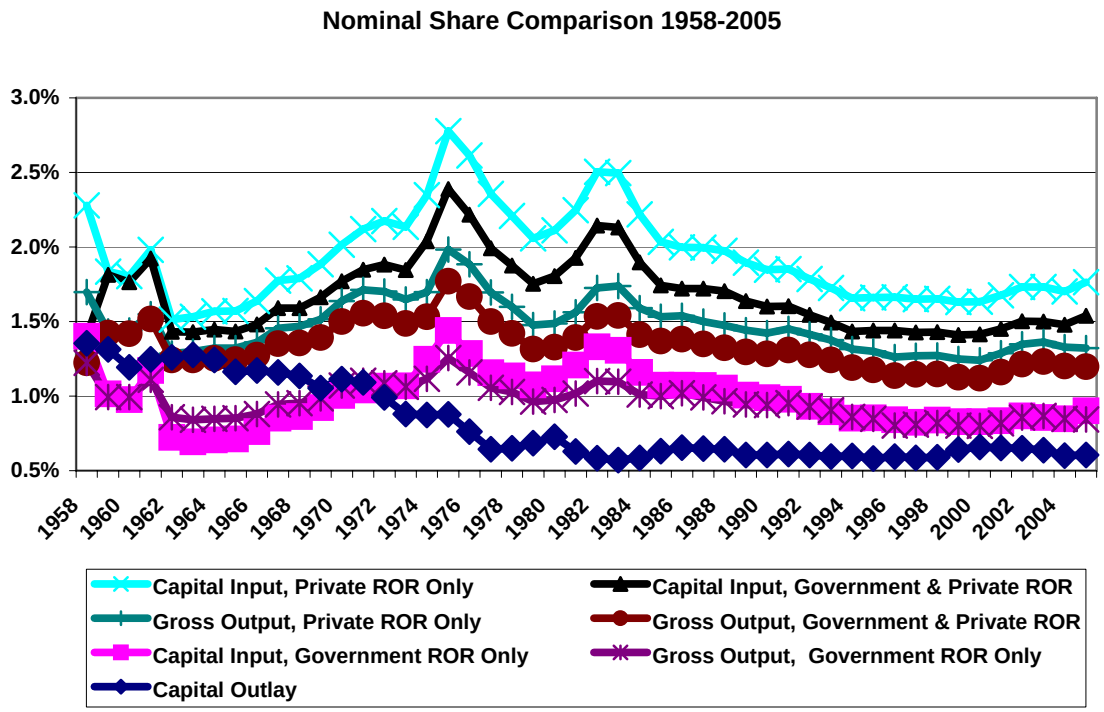
BEA and the Bureau of Labor Statistics (BLS) assume that the net own rate of return for all government assets is zero. Accordingly the estimated capital input and gross output

[9] Okubo et. al., 2006.

contributions, GDP and U.S. gross output are adjusted upwards. (BLS is the source for the U.S. gross output data.)

Highway gross output is equal to the sum of highway capital input and other than capital outlays on highways.

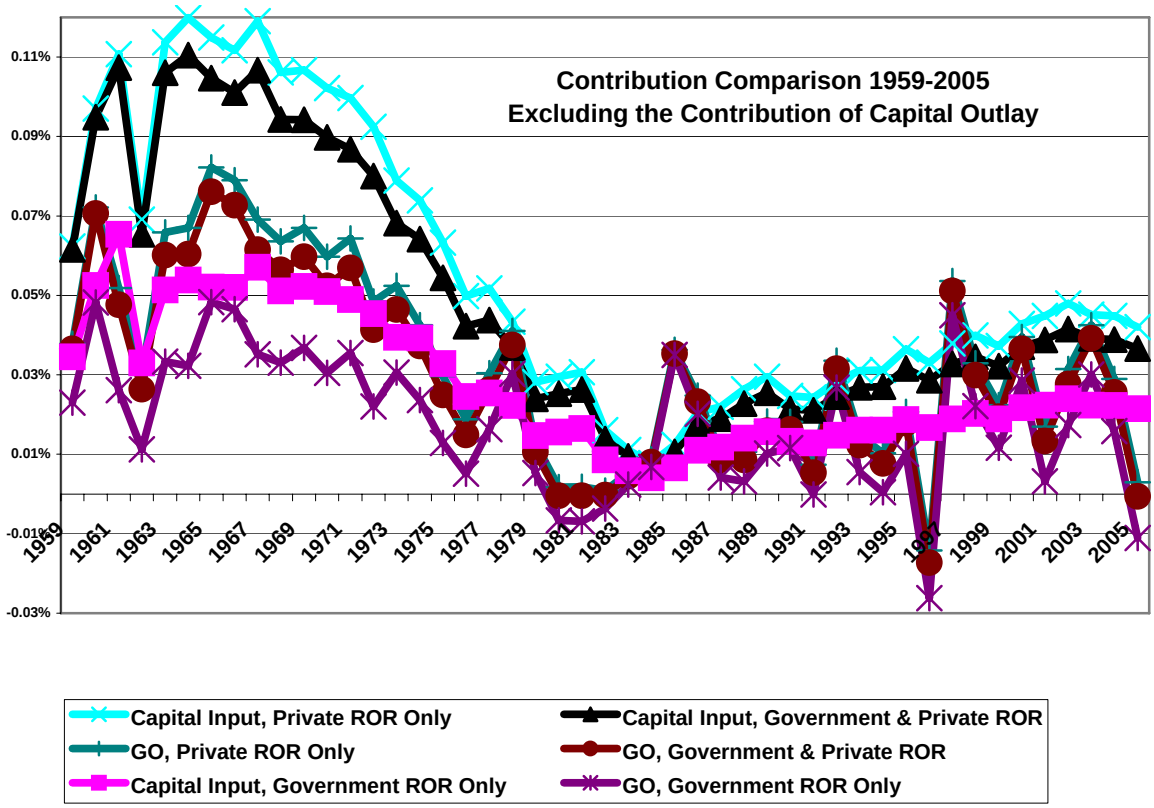
The following graphs the shares in the weighted rate of growth contribution formula.



The table below shows that the rate of growth of GDP is higher than any measure of the growth in highways (all in 2000 dollars). (The table and graph below begin in 1959 as all measures are available for these years.)

Percentage Average Rates of Growth 1959-2005		
Capital Outlay		1.28
Capital Input (Capital Stock)		3.00
Gross Output	Government Net Own ROR only	1.85
	Government & Private Net Own ROR	2.17
	Private Net Own ROR Only	2.25
GDP		3.34

The final chart graphs the highway contribution estimates. The analysis excludes the contribution of capital outlay to GDP growth from the graph because its' high degree of variability makes the graph difficult to read.



The contribution of highway capital input to adjusted GDP using a private net own rate of return for all assets is largest in most years. The contribution of highway gross output to adjusted U.S. gross output using a government net own rate of return for all years is smallest in most years. In all years the contributions are small except in the few years when the rate of growth of capital outlays is high. (These years are not shown.) The contribution estimates are small because the shares and 2000$ rates of growth are small.

Conclusion

This research estimates the contribution of highways to GDP growth in a manner that is directly comparable to BEA GDP contribution estimates. The resulting estimates of the contribution of highways to economic growth is small as distinct from measures which incorporate multiplier or spillover effects and the use of highways by households. This research perhaps most importantly provides productive highway capital stocks as inputs to other research.

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