Highway capital expenditures and induced vehicle travel

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ABSTRACT

We investigate the effects of public capital investment on the demand for travel. We define capital stock as a productive flow that accounts for the physical deterioration of infrastructure over time. We present a framework where additions to capital stock only cover a portion of the long-run equilibrium level, and where policy decisions are dictated by expectations of economic and travel growth. To the extent that these investments increase productivity, they generate induced travel. Using a panel dataset at the state level for the period 1982-2005, we find that the elasticity of travel demand with respect to changes in state highway capital stock is equal to 0.041in the short run, while the long-run is 0.237. Our results show that changes in capital expenditures in response to past levels of traffic are characterized by a three-year lag, suggesting that the investment response to changes in travel is slow to converge to the desired long-run levels.

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1. INTRODUCTION

There is a vast body of empirical research on the relationship between added capacity and vehicle travel. A detailed review of recent research is found in Noland and Lem [1], who also provide a summary of the various statistical approaches being used by researchers. The link between highway expansion and induced travel is usually modeled by regressing vehicle miles of travel (VMT), a measure of the demand for travel, on lane miles (LM), a measure of road supply. Underlying this relationship is the assumption that increased investment in roadway infrastructure (be it new roads or expanded capacity) provides a form of congestion relief, with added LM representing a proxy for reduced travel time costs. Adding LM reduces the overall cost of transportation and induces individuals to demand more travel.

Early empirical work [2] tests this relationship using ordinary least square regression (OLS) over a panel of urban area, counties or states, with a log level parametric specification of the form:

$$log\ (VMT_{it}) = \beta_0 + \beta_1 log\left(LM_{i,t-1}\right) + \beta_2 X_{it} + \varepsilon_{it} \qquad (1)$$

where the subscript *i* denotes the i^{th} urban area, state or county ($i=1,\ldots,N$) and the subscript *t* denotes the t^{th} year ($t = 1,\ldots,T$).

Under the above log-log specification, the parameter of interest (β_1) represents the short-run elasticity of VMT with respect to lane miles, or the elasticity of induced travel demand. Usually, a vector of controls (X_{it}) is added to the equation to account for state or county-specific economic and demographic characteristics. Different lag specifications of the dependent variable can be added to estimate if the impact of added capacity is contemporaneous or longer lasting. For example, using a panel of U.S. states over the period 1984-1996, Noland [3] finds elasticities ranging from 0.12 to 0.41 in the short and long-run.

One of the problems often cited in the literature is that the relationship between VMT and LM entails simultaneity and endogeneity. It is well known that road expansion plans are based on past and expected levels of traffic, making LM endogenous to the relationship. When more advanced frameworks are proposed, the relationship is modeled instrumental variable regression [3, 4], or by employing simultaneous equation models [5, 6]. As noted by Su [7], these approaches do not correct for serial autocorrelation arising from the inclusion of lagged endogenous variables and produce biased estimates. To correct for this problem, Su [7] resorts to dynamic panel estimation and finds expanding road capacity has much lower short run (0.07) and long run (0.26) effects on vehicle travel.

Notwithstanding these modeling issues, there is a consensus among researchers on the existence of induced demand effects. A challenge to this view is provided by Prakash et al. [8]. By using times series regression, Prakash et al. investigate the causality between road supply and induced travel to conclude that such linkage does not exist. In a rebuttal to this approach, Goodwin and Noland [9] criticize the improper use of capital expenditures data instead of lane miles as explanatory variables. In particular, Goodwin and Noland [9] argue that a proper analysis of road expenditure data shows that expenditures represent neither a good measure of added road capacity nor the role of a proxy variable for reduced time costs of travel.

In this paper, we revisit the use of capital expenditures and present a framework that compensates for the shortcomings of Prakash et al. [8], while at the same time addressing Noland's [9] criticisms. We propose an inter-temporal approach to capital investment, whose roots lay within the theory of capital optimization theory. Within this framework, expenditures in additional capital depend on a schedule of investment decisions that use past and expected levels of economic and travel growth. These expenditures are intended to add capacity, net of the outlays necessary to maintain the current stock of capital at its productive state. We argue that capital expenditures, when viewed within this framework, represent a more comprehensive predictor of induced travel demand. Indeed, the construction of new lane miles is part of a more comprehensive process, where investment decisions intended to accommodate for current and future increases in the demand for travel are addressed in the context of capital productivity enhancements. In addressing these claims we empirically revisit issues of endogeneity and simultaneity between travel demand and capital expenditures, which have implication on the estimation of induced travel demand elasticities.

2. HIGHWAY CAPITAL STOCK EXPENDITURES

We assume that capital expenditures influence the demand for traffic if the addition of new capital to the existing stock reduces the cost of travel at the margin. As argued in the previous section, a major critique to the use of highway capital expenditures as an explanatory variable for induced travel is that reported expenditures consist of both of non-adding capacity outlays, such as maintenance, resurfacing, and capacity-adding expenditures, such as widening, reconstruction and new lane miles. Using reported gross capital expenditures without making such distinctions hinders the outcome of the empirical effort [9].

To understand how capital outlays directed to add capacity or to improve the productivity of current infrastructure might influence the demand for travel, we adopt the concept of productive stock as opposed to that of wealth, which is better suited to estimate the market value of capital [10-19]. Whereas declines in wealth of capital are measured by the depreciation rate, declines in efficiency in the stock of productive capital are measured by the deterioration rate.

We adopt the definition of highway capital stock developed by Fraumeni [20], who also provides estimates at the national and state levels. Fraumeni [20] also constructs estimates of the deterioration to take into account pavement and grading differentials across structures (e.g., arterials, highways, bridges).

We assume that the decision to invest in new capital infrastructure is dictated by the need to maintain the existing stock of capital and by the current and expected demand for additional road capacity. If the demand for additional capacity can be ascribed by past and expected levels of traffic and economic growth, then we can summarize this relationship as

$$vmt_{it} = \alpha_0 + \alpha_1 vmt_{i,t-h} + \alpha_2 K_{it} + \alpha_3 \mathrm{X}_{it}^{\mathrm{vmt}} + \epsilon_{it} \tag{2}$$

$$I_{it} = \beta_0 + \beta_1 vmt_{i,t-h} + \beta_2 K_{i,t-1} + \beta_3 \mathrm{X}_{it}^{\mathrm{I}} + \epsilon_{it} \tag{3}$$

$$K_{it} \equiv K_{i,t-1} + I_{it} \tag{4}$$

where Equation (2) represents the demand for travel (with *i* indicating a county or state), which depends on current levels of stock of productive capital (K_{it}) as well as other factors, such as economic growth, population growth, number of licensed drivers, fuel prices (all included in the $\mathrm{X}_{it}^{\mathrm{vmt}}$ vector). In turn, the demand for new highway investment (I_{it}) depends on past and future levels of travel, as well as other factors affecting economic growth, such as state specific industrial mix and productivity levels (represented by the $\mathrm{X}_{it}^{\mathrm{I}}$ vector). While Equations (2) and (3) represent stochastic behavioral relationships, Equation (4) represents a non-stochastic equation showing that the stock of capital at the end of time *t* is equal to the sum of the existing capital ($K_{i,t-1}$) and new investment.

When viewed within this framework, new capital outlays consist of expenditures net of the necessary outlays to maintain the current stock at its productive levels. These expenditures are directed to increase capacity and therefore the productivity of capital. The expenditures of lane miles represent a subset of the overall expenditures directed at these productivity enhancements. Other capacity-adding expenditures include highway widenings to increase current capacity, reconstruction of bridges and other structures. In particular, the reconstruction of bridges provides enhancement in productivity as new technology enter into this type of capital stock.

Next, we refine the relationship between capital and investment to account for the fact that, for any time period, investment expenditures are planned to accumulate only a portion (λ) of the optimal long-run level of capital (K_t^*). We assume that at any given time period the stock of capital is replenished by an optimizing behavior that fills the gap between (K_t^*) and the current capital stock so that at the end of time *t* capital will be equal to:

$$K_{it} = K_{i,t-1} + \lambda\left(K_{it}^* - K_{i,t-1}\right) \tag{5}$$

As indicated by Equation (4), to increase the stock of capital from K_{t-1} to K_t, the amount of net investment must be equal to $I_t \equiv K_t - K_{t-1}$. Therefore, net capital investment expenditures can be re-written as

$$I_{it} = \lambda\left(K_{it}^* - K_{i,t-1}\right) \tag{6}$$

Equation (6) shows that the greater the gap between the optimal and actual levels of capital the higher the net investment. What factors the speed of adjustment λ depends upon remains to be empirically established. As acknowledged by the literature on capital optimization theory [19, 21, 22], and on the relationship between public capital an economic productivity [13, 15, 23], any factor that influences the desired stock of capital also increases net investments.

The dynamic behavior of Equation (6) depends on two factors. The first factor is linked to expectations. The desired capital stock K_t^* depends on government prospects regarding future traffic levels and the extent to which expected growth is temporary or permanent in nature. The degree to which state governments estimate the demand for travel is based on past levels will be reflected by lags between the desired level of capital and the demand for travel. This adjustment will inevitably have an impact on the investment levels.

The second factor is related to delays in the process of adjustment itself due to the decision to fill only a fraction of the gap at each period. Transportation policy decisions to invest in additional highway capital infrastructure are based on long-term transportation plans which rely on past and expected levels of traffic growth. Expected increases in state economic output or population growth put pressure on the demand for additional travel (both private and commercial) and, therefore, on the demand for additional highway capital infrastructure. This, in turn, influences future decisions to invest in additional highway capital, or at least in a fraction of the optimal long run level. To examine the effect of these factors, we replace K_t^* in Equation (6) with

$$K_{it}^* = f(vmt_{i,t-h}, X_{i,t-h}) \tag{7}$$

where $X_{i,t-h}$ is a vector of lagged controls for state specific socioeconomic factors and $vmt_{i,t-h}$ represents lagged values of VMT from Equation (2) to indicate dependency upon current, past or expected levels of travel. Substituting Equation (7) in Equation (6), we obtain

$$I_{it} = \lambda f(X_{it-h}) - \lambda K_{it-1} \quad (8)$$

To show the inherent relationship between the demand for travel and investment in highway capital infrastructure of (3), we re-write (8) as

$$I_{it} = \beta_0 + \beta_1 vmt_{i,t-\mathrm{h}} + \beta_2 K_{i,t-1} + \beta_3 X_{i,t-h} + \epsilon_{it} \quad (9)$$

Given Equations (2) and (9), the relationship between demand for travel and supply of road capacity is no longer simultaneous but sequential. Although K_{it} is predetermined in Equation (2), it is endogenous to the system by way of Equation (9) and the identity in (4). In this framework, the time path of capital accumulation is one where public agents choose a growth path that is intended to maintain the current stock at its productive levels and to invest into a fraction of the optimal, long-run, level. This fraction depends upon expectations of economic and travel growth. To the extent that new capital effectively reduces the cost of travel at the margin, one can postulate an increase in travel demand beyond those levels that accompany economic growth (i.e., induced vehicle travel). Next, wet proceed to empirically test this relationship.

3. DATASET AND EMPIRICAL MODEL

To maintain congruency and to compare our findings with the previous literature, we employ a panel dataset of 50 U.S. states over the period 1980–2005, using motor vehicle travel data from the Highway Statistics Series, and additional economic and socio-demographic characteristics from a variety of sources. The various data sources, variable definitions are discussed in the appendix. Table 1 lists the variables and provides basic descriptive statistics.

TABLE 1 Pooled Sample Descriptive Statistics

Variable Name	*Definition*	*Mean*	*Standard Deviation*	*Minimum*	*Maximum*
vmt	VMT per capita (miles)	9,152	1,894	4,410	18,352
inc	per capita disposable income ($)	14,333	2,402	8,653	21,678
urban	fraction of state population leaving in MSAs	0.72	0.19	0.29	1.00
fuel_c	fuel cost per mile ($)	0.06	0.02	0.03	0.14
k	per capita stock of productive capital ($, million)	5,145	5,189	625	38,387
cidx	construction cost index	118.62	23.72	87.60	183.60
gdp	gross state product ($, million)	104,233	125,257	6,734	916,671
industry	industry diversity index	0.15	0.02	0.11	0.30
pdrivers	proportion of population with licensed drivers	0.68	0.05	0.51	0.90
vadult	number of vehicles per adult	0.72	0.10	0.26	1.04

3.1 ESTIMATION METHODS

Several econometric issues arise from estimating Equation (2). As discussed in the previous section, the stock of productive capital K_{it} is predetermined but endogenous, with causality running in both directions, from K_{it} to vmt_{it} and vice versa. In addition time-invariant factors specific to a state, v_i, may be correlated with the explanatory variables. These could include geographical differences that influence travel patterns or other unobservable factors that might impact growth in income or population. These fixed effects are part of the error term in Equation (2), which also include observation specific errors, μ_{it}, defining $\varepsilon_{it} = v_i + \mu_{it}$. The μ_{it} component includes measurement errors, because states use different methods to report estimates of VMT and capital expenditures, which also vary across the years.

Another issue is related to time dependence, which results in series that are not stationary over time. Visual inspection of the series suggests both VMT and income are non-stationary and tests of the hypothesis of unit root in the first differences by state are rejected to conclude that the series are all co-integrated of order one. The econometric literature shows that the FE estimator is sensitive to measurement errors that lead to biased and inconsistent estimates [24, 25].

First-differencing of Equation (2) produces results that are comparable to those of a fixed effect model with time demeaning behavior, removing non-stationarity, reducing measurement error dependence, and eliminating unobserved time-invariant effects:

$$\Delta vmt_{it} = \alpha_0 + \alpha_1 \Delta vmt_{i,t-h} + \alpha_2 \Delta K_{it} + \alpha_3 \Delta \mathrm{X}_{it}^{\mathrm{vmt}} + + \Delta\epsilon_{it} \tag{10}$$

It is easy to show that under the first-differencing transformation, ΔK_{it} is equivalent to[1]:

$$\Delta K_{it} = f\left(vmt_{i,t-h}, X_{i,t-h,} K_{i,t-1}\right) = I_{it} \tag{11}$$

where (11) shows how the change in capital depends from previous travel levels ($vmt_{i,t-h}$) and economic growth ($X_{i,t-h,}$), underscoring how the demand for investment depends on rational expectations regarding economic and travel growth.

Keane and Runke [26] argue that dynamic panel data models for testing rational expectations using individual-level data generally do not satisfy the required strict exogeneity assumption of fixed effect models. Such is the case when a lagged explanatory variable is correlated with the error term because of its dependence upon previous values of the dependent variable. To preserve the less restrictive assumption of sequential exogeneity, Wooldridge [25] and Baltagi [24] propose the use of lags of the dependent variables as instruments.

This approached is detailed in Arellano and Bond [27], who propose a more efficient estimator based on generalized method of moments (GMM) to address endogeneity. The estimator consists of a system of equations in both first-differences and levels where the instruments used in the levels equations are lagged first-differences of the series. The Arellano-Bond difference GMM estimator might perform poorly in the presence of persistent time series and in the presence of weak correlation between the lagged levels and the first differences (i.e. weak instruments). This problem is recognized by Arellano and Bover [28] and Blundell and Bond [29], who improve the estimator by including both lagged levels as well as lagged differences. This improved estimator is commonly referred to as *system* GMM.

[1] Since $K_{t-1} - K_{t-2} = I_{t-1}$.

We use *system* GMM regression (system GMM) to estimate Equation (2) and compare the results of OLS and fixed-effect (FE) models to gauge the validity of our results and to assess the extent of biased of the OLS and FE results. To estimate system GMM, we employ the Stata command *xtabond2* written by Roodman [30], which offers several additional features to the Stata default *xtdpdsys* package, including automatically generated difference-in-Sargan/Hansent tests, and the ability to control (by using the subcommand *collapse*) the number of instruments. The latter feature represents and advantage due to biased and overfitting issues arising from the use of too many instruments. Roodman [26] warns how the use a large number of instruments might lead to the selection of suspect instruments which can weaken the Hansen overidentification test (i.e. unrealistic p values of 1.000) and overfit the endogenous variables.

We instrument Equations (10) and (11) using lagged values of the of the variables in level as instruments, and employ additional instrumental variables for K_{it} to reflect the relationship described in (*3*) and (*9*). These additional instruments, in lagged form, account for changes industry composition (*industry*), a highway construction cost index (*cidx*), and past gross domestic product levels (*gdp*).

5. RESULTS

We omit the District of Columbia from the analysis, since it represents a clear outlier in terms of capital investment expenditures and productive stock of capital. The estimated coefficient of the lagged value of VMT is 0.83, an indication of how vehicle travel depends on established travel patterns. The coefficient is in the range of 0.73 to 0.94 of the FE and OLS models, confirming OLS inherent bias spanning from the omitted variable and endogeneity. Note that the OLS attributes all the relationship between the stock of capital and VMT as causal, but it does not account for reverse causality.

Improving upon the OLS model, the time-demeaning behavior of the FE eliminates the time constant unobserved heterogeneity. But, as in the OLS model, the FE precludes the presence of feedback effects of $vmt_{i,t-h}$ on K_{it} by way of I_{it}, as formulated in Equation (9).

The system GMM regression treats the stock of productive capital (*k*) as predetermined but endogenous to the system. Vehicle stock per adult (*vadult*) and fuel cost per mile (*fuel_c*) are treated as fully endogenous.

The short-run elasticity of in vehicle miles of travel with respect to changes in capital stock expenditures is 0.041, while the long-run elasticity is 0.237 (computed as 0.048/1-0.828). These estimates are substantially lower than the ranges of previous research [1, 3, 4], but within the ranges of the more advanced model proposed by Su [7] and Hymel et al [5].

Table 2 also reports some performance statistics for the system GMM instruments. The validity of the system GMMS estimation hinges on the assumption that the instruments are exogenous. Arellano and Bond [27] derive the test for autocorrelation of order *m* of the first differenced errors. Under the null hypothesis, it is assumed that there is no second-order autocorrelation and, therefore, the use of lagged values of the dependent variable as instruments leads to misspecification. Failure to reject the null of second-order autocorrelation, as indicated by a *p-value* of 0.06 provides support to the validity of instruments. As an alternative, the test for Sargan for over-identification restriction provides a way to assess the overall validity of the instruments. In estimating the model we follow Roodman [30] to set up minimum number of instruments and the *collapse* option when running Stata command *xtabond2*. The final model uses 37 instruments, which is less than the total number of observations per group (50).

TABLE1 Results by Model Specification

	Regression Model		
Variable	*OLS*	*FE*	*System GMM*
ln(vmt) L1	0.941***	0.725***	0.828***
	(0.00776)	(0.0160)	(0.0287)
ln(k)	0.00281*	0.0142*	0.0407***
	(0.00160)	(0.00765)	(0.00762)
ln(fuel_c)	-0.0857***	-0.170***	-0.171***
	(0.00967)	(0.0121)	(0.0195)
ln(vadult)	0.00636	0.0178**	0.0146**
	(0.00628)	(0.00893)	(0.00663)
ln(inc)	-0.0156**	0.109***	0.0159
	(0.00785)	(0.0221)	(0.0112)
ln(urban)	-0.0131**	0.210***	0.0285**
	(0.00404)	(0.0381)	(0.0117)
ln(pdrivers)	0.0180	0.0298*	0.0555***
	(0.0114)	(0.0166)	(0.0150)
Constant	0.463***	1.028***	0.701**
	(0.104)	(0.198)	(0.256)
R^2	0.9815	-	-
R^2 within	-	0.9707	-
F	21.4.86	1248.67	-
Wald chi^2	-	-	65967.48
Arellano-Bond test for AR(1): p-value	-	-	0.000
Arellano-Bond test for AR(2) p-value	-	-	0.064
Sargan test of overidentifying restrictions	-	-	0.088
Difference-in-Sargan tests of exogeneity of instruments: p-value	-	-	0.255
Number of instruments	-	-	37
Number of observations	1250	1250	1250

*Absolute value of standard errors in parentheses: *p<0.10, **p<0.05, ***p<0.001*
Year dummies omitted

6. DISCUSSION

We argue that by looking only at the relationship between added lane miles and observed traffic levels, one only partially captures such effects with the danger of falling into a mere assessment of a spurious relationship. This problem has been sparely acknowledged by the literature, where methodological problems often result in an overstatement of the induced demand effects [31]. Questions about the causality between traffic and road capacity require to look beyond the statistical relationship one may find between lane miles and VMT, and to define a framework where road demand and investment jointly influence each other over the long run.

This paper contributes to this field of research by proposing an approach that takes into account both endogeneity and simultaneity between travel demand and the pressures it imposes on transport infrastructure. In this context, investments in added road capacity take the form of proportional increases in the stock of highway capital. We define capital stock as a productive flow that accounts for the physical deterioration of infrastructure over time. Additions to this stock only cover a portion of the long-run equilibrium level of capital. Investment decisions are dictated by expectations of economic and travel growth. To the extent that these investments increase productivity, they generate induce travel.

We empirical tests this relationship to reveal that capital investment on additional capacity, *ceteris paribus,* has a minor impact on the short-run and long-run demand for travel. These findings add to the debate about the productivity of public capital.

The modeled changes in investment from period to period reflect an assessment of these effects that corresponds to a short-run assessment of how public capital stock fluctuates in response to changes in past economic activity and traffic levels. Empirically, these changes in expenditures in response to past levels of traffic are characterized by a three-year lag, suggesting that the investment response to changes in travel is slow to converge to the desired long-run levels.

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APPENDIX: DATA SOURCES

Consumer Price Index – All Urban Consumers, by Region (1982–84=100)

Bureau of Labor Statistics – CPI (www.bls.gov/cpi). Note: all monetary variables (income, fuel price, highway capital stock, highway capital expenditures) are transformed in real 1982–1984 dollars by deflating using this series.

State Highway Capital Stock ($ billion, adjusted to real dollars using CPI series)

U.S. Department of Transportation, *Federal Highway Administration (FHWA);*

Productive Highway Capital Stock Measures

The construction of the state highway capital series is obtained by using the state aggregate estimates from Fraumeni [20]. The report provides estimates for the period 1921–1995 (http://www.fhwa.dot.gov/reports/phcsm/stkvalus.xls). . Estimates for the period 1996–2005 were obtained by fitting an ARIMA (1,1,1) over the 1921–1995 series:

$$\Delta^1 k_t = k_t - k_{t-1} = \alpha_0 + \varphi_1 \Delta^1 k_{t-1} + \epsilon_t - \theta \varepsilon_{t-1} \quad (1)$$

with the estimated values of $\alpha_0 = 6.042$ and $\varphi_1 = 0.849$. To obtain the 1996–2005 forecasts, (1) was back transformed as follows:

$$E_{k_{n+h}} = k_n(h) = (1 - \varphi_1)\mu + (1 + \varphi_1)k_n(h-1) - \varphi_1 k_n(h-2)$$

where h = periods ahead; μ = mean from the sample. In deriving the mean, all future error terms assumed by construct to have mean 0, that is $E(\epsilon_{n+h}) = 0, h > 0$

The aggregate state estimates were attributed to the states by multiplying the total by each state's share of total rural plus urban highway mileage. The final series is estimated for the period 1980–2005.

Highway Capital Expenditures ($ billion, adjusted to real dollars using CPI series)

Capital expenditures used to create the variable(I), only include the following types: Right of Way (ROW), engineering, new construction, relocation, reconstruction that adds capacity, major widening, new bridge.

- 1980–1995: FHWA, *Highway Statistics Summary to 1995*, Table SF-212. In addition, Table SF-212A was employed to break capital expenditures by type.
- 1996–2005: FHWA, *Highway Statistics*, annual editions, Table SF12-A

Population: midyear population

U.S.Census Bureau http://www.census.gov/popest/estimates.php

Price of Gasoline (cent/gallon, adjusted to real dollars using CPI series

Urban and Rural Road Mileage

Measured in total length of roads by state (miles):

- 1980–1995: FHWA, *Highway Statistics Summary to 1995*, Table HM-220
- 1996–2005: FHWA, *Highway Statistics*, annual editions, Table HM-20
- *Number of Licensed Drivers*
- 1980–1995: FHWA, *Highway Statistics Summary to 1995*, Table DL-201
- 1996–2005: FHWA, *Highway Statistics*, annual editions, Table DL-1C

Urbanization

Share of total state population living in Metropolitan Statistical Areas (MSAs), Source: Bureau of Economic Analysis, Regional Economic Accounts (http://www.bea.doc.gov/bea/regional/reis/)

Education

Percent of the Total Population 25 Years and Over with a Bachelor's Degree or Higher by Sex, for the United States, Regions, and States:

- 1980–2000: U.S. Census Bureau Census 2000," A Half-Century of Learning: Historical Statistics on Educational Attainment in the United States, 1940 to 2000", Table PHC-T-41
- 2001–2005: U.S. Census Bureau, Table 218; Source: http://www.census.gov/population/www/socdemo/educ-attn.html

Gross Domestic Product ($ billion, adjusted to real dollars using CPI series)

Source: Bureau of Economic Analysis (BEA) http://www.bea.gov/regional/gsp/

Income

Source: Source: Regional Economic Information System, Bureau of Economic Analysis, U.S. Department of Commerce (BEA) http://www.bea.gov/regional/spi/SA1-3fn.cfm

Per Capita Personal Income ($/year, real dollars)

Personal income divided by total midyear population. This is the primary measure used in the analysis.

Per Capita Disposable Income ($/year, adjusted to real dollars using CPI series)

Directly available from the BEA

Vehicle Miles of Travel (millions)

- 1980–1995: FHWA, *Highway Statistics Summary to 1995*, Table VM-202
- 1996–2005: FHWA, *Highway Statistics*, annual editions, Table VM-2