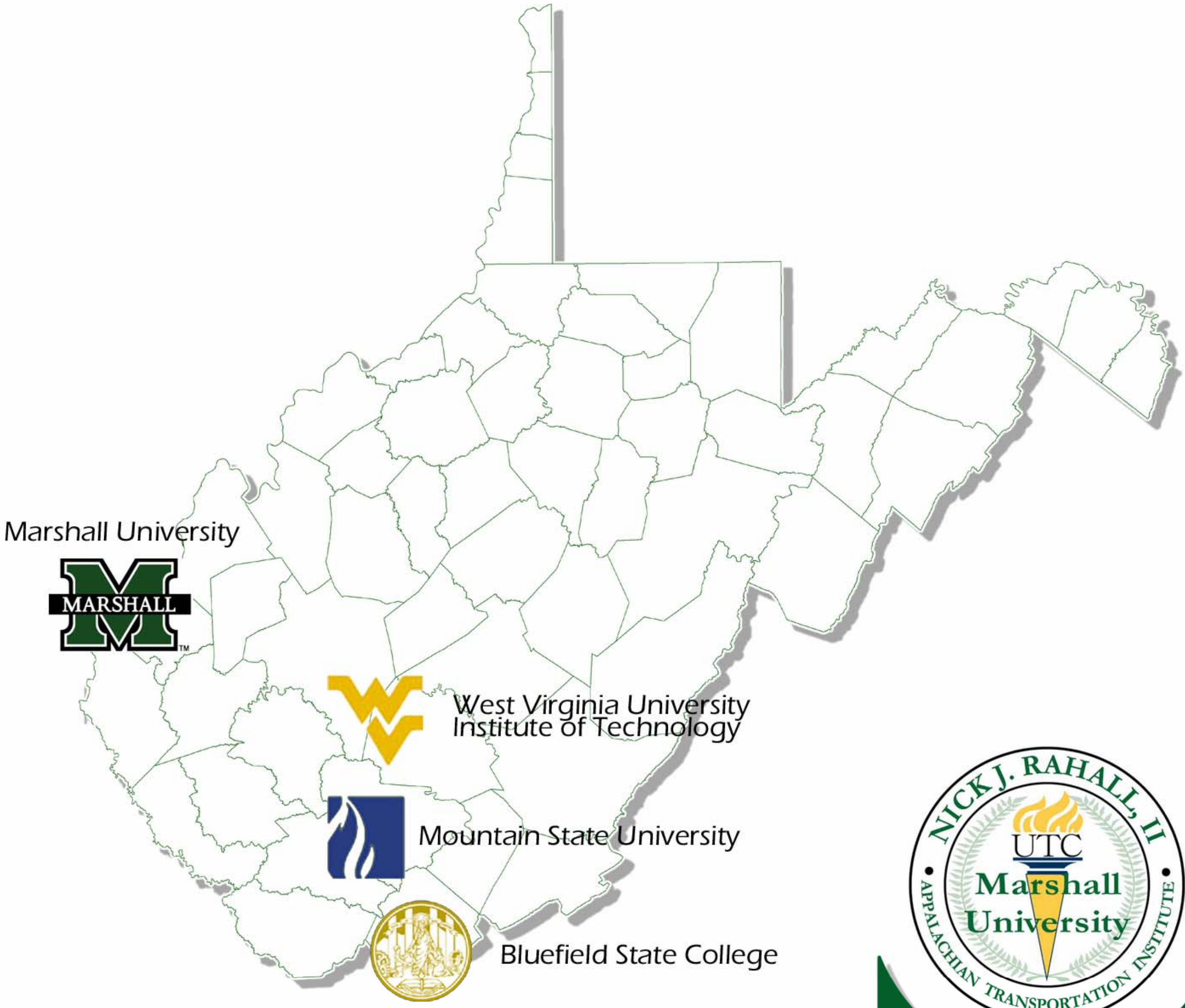
TRP 99-15 Impacts of Appalachian Development Corridors on Small Business: Evidence from Corridor G



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16. Abstract
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Impacts of Appalachian Development Corridors on Small Business: Evidence from Corridor G

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Introduction

Advocates of aggressive infrastructure policies face a sobering set of recent research findings regarding the efficacy of public expenditures on new highways. The exuberance of the growth enhancing possibilities of infrastructure that was so apparent in the late 1980's and early 1990's has given way to a more cautious interpretation of the data. Simply, most newer studies find limited economic development benefits to highway construction.[1] Notably, the other economic benefits (safety, travel time reductions, environmental improvements) remain largely unexplored by these studies. In response, a number of scholars have increased their calls for additional research into these issues.

This study responds to these concerns and performs more disaggregated research into the impacts of highway construction. The paper proceeds as follows: a brief review of the study area, a description of what constitutes economic benefits of highway construction, a review of new growth theory and the contribution of infrastructure in endogenous growth models, and three models of highway impacts: firm level productivity, regional productivity and sustainability measures. Each are tested, in turn and are followed by summary and conclusions. The appendices include specific data on the sampled area – Corridor G, from Charleston, West Virginia to Pikeville, Kentucky.

Corridor G

Corridor G is one of 26 roads in the Appalachian Development Highway System. The region comprises the northern part of the West

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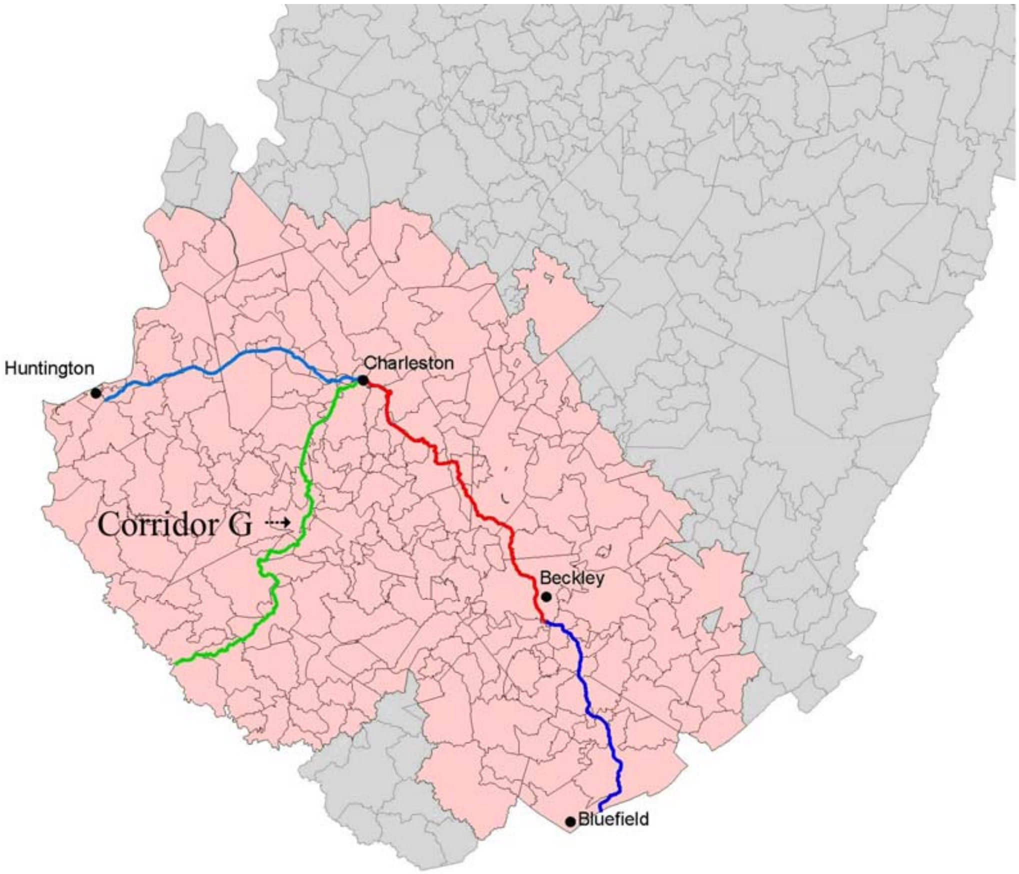
[1] The most recent empirical work that best corrects for spatial and time series endogeneity rejects positive growth impacts of physical infrastructure (e.g. Holtz-Eakin, 1994; Chandra & Thompson, 2000). These findings ought to present concern to policymakers considering the application of infrastructure investment as a means of generating broad regional economic growth. This concern should focus research into the microeconomic relationship of public infrastructure to growth, at very low levels of aggregation or at the firm level. That is what this research, in part, seeks to answer.

Virginia/Kentucky coalfields. The West Virginia Portion was completed in 1997 and as the road is completed through Kentucky it will comprise a four-lane, limited access road from Pikeville, Kentucky to Charleston, West Virginia. See Figure 1.

Figure 1, The Corridor G Region, Charleston to Williamson, West Virginia



The area has experienced considerable economic turbulence in the past two decades. The halving of coal prices that led to rapid loss of coal related jobs from 1984 through the mid-1990’s had a profound effect on the coal mining counties in the region. The ill effects of the lost mining employment continued to impact the region in the years since. This region served as an ideal example of the type of location intended to benefit from the construction of an Appalachian Development Highway.

Economic Benefits of Highways

Evaluating the economic consequences of highway construction, operations and maintenance has resulted in the deployment of considerable resources in academia, government and the private sector. Though a full discussion of the methods employed in these studies is well outside the scope of this research, it is important to understand broadly what questions are asked regarding the impact of highway construction.

Economic benefits of highways are not confined to employment and income growth; they also encompass changes to individual utility. Changes to employment and income are often referred to as economic development impacts, while changes to individual utility are more commonly referred to as travel efficiency or environmental benefits. Together, these form the bulk of economic benefits to infrastructure construction.

Researchers typically measure changes in aggregate or sectoral employment within regions generated by highway construction. Also, measures of reduced cost (leading to greater efficiency) to firms typically comprise parts of these studies. These are the prime source of economic development benefits.

Individual utility is analyzed through a variety of impacts from changes in commuter travel time to changes in levels and patterns of emissions associated with different types of transport. Estimates of these benefits are typically employed in studies evaluating the benefits and costs of infrastructure construction. Also, recent studies that evaluate aggregate economic impacts find large benefits to utility relative to economic development impacts (see Global Insight and Wilbur Smith Associates, 2003).

Clearly this study process can be time-consuming and challenging. Perhaps the greatest difficulty for researchers is separating true gains from transfers from one segment of the economy to another. An example is the concentration of economic activity along new highway construction. While this may appear as an economic development benefit it is not if the regional growth resulted from the relocation of economic activity from regions without roads to areas of new highway construction. Similarly, reductions in the price of goods, for example airfares, would not meet the standard of an economic benefit unless they were associated with actual cost differences. This is so because price reductions not associated with underlying cost changes are simply a transfer of benefits from producers to consumers.

This study will directly test the economic development benefits, particularly to small businesses, of construction of Corridor G using several novel approaches. The theoretical underpinnings of this analysis are based upon advances in economic theory that suggest that productivity benefits to firms should occur as a result of their concentrating economic activity along highway infrastructure. The questions posited in this study arise from concerns posed by an important analysis of highway construction (Chandra and Thompson, 2000) which found that virtually all regional economic growth associated with the Interstate Highway System could be attributed to the relocation of economic activity from counties not directly serviced by the highway system. This would be an example of economic benefits being transferred from one region to another.

However, economic theory would also suggest that the concentration of this economic activity should enhance efficiency through increasing returns. If this is indeed the case, then the shifting of economic activity would be more than a transfer. This is naturally an empirical question, which this study explores.

This analysis was designed to evaluate the impact of Corridor G on small businesses.[2] In order to do this it was necessary to evaluate, in each instance, the overall impact of the Corridor on economic activity and impute, or directly estimate the impact on small business. In order to better frame the results presented in the following sections, we note that in no instance was a difference in impact attributed to firm size. However, a non-trivial impact to economic activity as a whole was noted. These results form the bulk of this report.

NEW GROWTH THEORY AND PUBLIC INFRASTRUCTURE

A broadly hypothesized part of *New Growth Theory* is the existence of constant or increasing returns to scale inherent in public infrastructure and human capital. This is an important departure from neoclassical growth theory's reliance on diminishing returns to scale for all inputs. The *New Growth Theory* models growth as a result of firm behavior when faced with constant or increasing returns to public investment. The optimal firm behavior generates growth through the input-substitution effect in which the individual firm reduces production costs without additional private capital investment. While the genesis of the modeling was in the elucidation of macroeconomic convergence, the inference for a non-neutral capital investment policy is apparent. Simply, physical infrastructure (highways in this case) may increase productivity at a non-diminishing rate.

The theoretical underpinnings of the models are well established. It is in the empirical evaluation of returns to scale generated by capital investment that continuing research is greatly needed. Also, simple growth correlation, which has received mixed empirical support, is of interest within this context. While it will not be addressed in this study, we place no strict assumptions on the transmission mechanism for

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[2] The US Small Business Administration identifies small business as those with fewer than 500 employees. For our purposes, we will show impacts on firms with employment ranges up to 500 employees.

productivity impacts of infrastructure. These may be demand side arising from reduced customer costs. Or they may be supply side impacts associated with lower costs per unit produced. In either case we can investigate this through the use of production function (which under reasonable assumptions in the long run is the dual of the cost function). In any case, it is likely that the differentials in demand and supply side impacts are industry specific which may be reflected through specification adjustments for individual industries.

This study outlines a method for testing the microeconomic foundations of growth theory with special application to a spatial setting. The focus here is on physical infrastructure – primarily highways, along Corridor G.

Approach 1: A Regional Growth Model

A common regional production function model is employed in this analysis. This differs in form from the firm production function presented later in two respects: the level of aggregation and the empirical specification. The model presented is a pooled Spatial Vector Autoregression with exogenous variables. The model is thus:

Equation 1

$$\frac{PCIncome}{pop} = \alpha + \beta_1\left(\frac{PCIncome}{pop}\right)_{t-n} + \beta_2\left(\frac{Edu}{pop}\right)_{t-n} + \beta_3\left(\text{Construct Income}\right)_{t-n} +$$

$$\mathrm{L} \; + \beta_4\left(W * \frac{Emp_i}{pop}_{\;j}\right)_{t-n} + \beta_5\left(Trend\right)_t + \beta_6\left(HWY119\right) + \varepsilon_t^i$$

In this form per capita income is a function of lagged dependent variables, exogenous variables and a spatial autocorrelation component regressed on panel data. The dependent variables are the components of a basic growth model: income growth, human capital and physical capital. The exogenous variables are the trend and Highway presence dummy. We will refer to the spatial autocorrelation variable in a separate category for technical reasons.[3] This is a fairly contemporary specification.

In order to fully populate this model with data, the use of a number of common proxies and econometric adjustments is helpful. All variables are for each of the West Virginia and Kentucky counties contiguous to Corridor G, the highway under investigation in this study. The data are from 1978 through 2000. The dependent variables are years of education per capita in the counties as a proxy for human capital and real construction income as a proxy for physical capital. The independent variables are time/presence dummies for the construction and completion of the West Virginia segment of the highway.

The human capital variable is the total years of education. A few comments are warranted for this common proxy variable. Human capital measurements are difficult to make across regions that suffer great variability in culture, educational attainment, or health care access. But, for states like West Virginia and Kentucky more simple measures are likely to provide sufficient variability to reflect actual human capital differences.[4] That is the goal of employing a proxy variable in this type of model. This approach is especially acceptable since this study is not intended to directly estimate human capital impacts, only control for their presence.

The model includes a trend component that provides for a correction necessary for observing changes over time in a model that does not include random or time varying effects (Baltagi, 1996). The use

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[3] A fuller technical explanation of this approach, which will appear in the final report, requires testing for strict exogeneity of the variables. A more loose definition of exogeneity is used in this specification which fails to preclude statistical bias in a few applications. It is unlikely this presents qualitative problems in this model. More clearly, the spatial autocorrelation function and construction income may well not be strictly exogenous (though construction income has been omitted from the growth component).

[4] Within the observed region there are very few differences in regional human capital components unrelated to education. In particular, regional differences in health care outcomes are quite similar, and likely experience high covariance with education, making their omission appropriate both due to theory and the problem of collinearity in an estimation model.

of a common intercept is appropriate due to the necessity of including spatial interaction terms. This differs from earlier studies of this type that used a fixed effects model (Holtz-Eakin and Schwartz, 1995). The selection of the appropriate panel model has been subject to much debate in the literature beyond even the spatial and autoregressive issues of the estimators (see Baltagi, 1996). A panel model with a common intercept appeared to be most appropriate specification. This specification permits both cross sectional and time varying components to be estimated. A longer set of observations will likely be necessary for alternative models to be fruitfully employed. These choices were rather easy in this instance since a fixed effects model may be incompatible with spatial interaction terms (Anselin, 2001). Standard errors were White-washed with White's heteroscedasticity invariant variance-covariance matrix.[5]

A comment on the spatial autocorrelation function is also warranted. This spatial component is a common technique in regional analysis. The estimation of a spatial component involves the use of a weighted and normalized set of observations of the dependent variable in contiguous counties in time *t*. This accounts for the regional impact of contiguous counties in the model. The interpretation of this component is the impact of adjacent counties on the dependent variable (per capita income). Its inclusion does correct for the very real problem of spatial autocorrelation (Anselin, 2001).

The choice of appropriate lag lengths is also a much debated point in the literature. The use of a vector autoregressive model is recommended when the theoretical structure of the model contains doubt as to the timing of impacts. This is a clear case where that is appropriate. The model is not sensitive to variation in lag length, and indeed, the Akaike Information Criterion is minimized with one lag. This

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[5] This common technique is employed to improve the efficiency of the estimate, permitting better analysis through adjustment of the standard errors to account for heteroscedasticity.

leaves a single lag as the appropriate selection, though it seems to matter little in terms of magnitude or significance of the estimates.

The choice of pooling the estimates or permitting them to vary by individual cross section is another choice in panel models that has not received consensus opinion in the econometric literature. In this case, permitting at least the highway construction impacts to vary at the individual cross section seemed warranted. The magnitudes and significance of the other variables were unaffected by pooling or allowing for cross sectional variation. A choice to pool them was arguably arbitrary, but not of much difference in the final results. The first differences of the variables were used. These reduce the explanatory power of the model, and would oftentimes recommend the use of a cointegrating equation which is not feasible here for a variety of reasons, primarily related to sample size (though clearly here, application has outstripped method in econometrics). The only real concern that motivated the use of first differences is the failure to reject at high levels of significance stationarity in many of the variables in common unit root tests. Again, the choice here is made on the side of caution, trading an excessive amount of explanatory power for assuredness that a spurious regression is not the result.

Table 1, County Level Growth Models, Change in non-construction per capita income is dependent variable, t-statistics in parenthesis.

Variable	Spatial VEC-Growth model	Spatial VEC-Growth w/ highway presence dummy	Fixed effects treatment model w/ highway presence dummy
C	-0.023418*** (-2.27)	-0.033963*** (-2.56)	----
Δ non-construction income, t-1	-1.819008 (-1.14)	-2.861410* (-1.73)	----
Δ education per capita, t-1	4.247465** (2.43)	2.657269* (1.80)	----
Δ construction income, t-1	3.62E-07* (1.69)	-4.98E-07 (-1.49)	----
Δ spatial matrix, t-1	-1.495424 (-1.49)	-2.534525 (-1.54)	----
Δ non-construction income, t-2	-0.718482 (-0.57)	-1.105772 (-0.96)	----
Δ education per capita, t-2	1.146541 (0.62)	0.736243 (0.399)	----
Δ construction income, t-2	5.46E-07*** (2.755)	4.96E-07*** (2.98)	----
Δ spatial matrix, t-2	4.008781** (2.003)	3.069631* (1.81)	----
BOONE--TREND	----	0.002721 (1.33)	----
KANAWHA--TREND	----	0.005195*** (3.19)	----
LINCOLN--TREND	----	0.003009*** (3.03)	----
LOGAN--TREND	----	0.000555 (0.41)	----
MINGO--TREND	----	-0.000246 (-0.18)	----
PIKE--TREND	----	0.000161 (0.10)	----
BOONE--HWY119 Completion	----	0.001684 (0.036)	0.01 (1.00)
KANAWHA--HWY119 Completion	----	-0.053586** (-2.20)	-0.008* (-1.79)
LINCOLN--HWY119 Completion	----	0.000462 (0.033)	0.016*** (2.85)
LOGAN--HWY119 Completion	----	0.010228 (0.36)	-0.02 (-1.31)
MINGO--HWY119 Completion	----	0.009209 (0.29)	-0.02 (-1.31)
PIKE--HWY119 Completion	----	0.042195 (1.20)	0.016 (1.41)
Adjusted R-squared	0.30	0.43	0.04
F-statistic	2.800	3.27	3.31

Interpretation of the results for the first of these models is straightforward. First, the education coefficients are consistent with other studies in its direction and magnitude. Education per capita is the proxy for human capital. These results hold also for the construction income coefficient, the proxy for physical capital. Non-construction income (the lagged dependent variable illustrated here) and the spatial matrix are neither important in terms of interpretation for the purposes of this research.

The second model, which includes the highway presence dummy and trend within the growth model tell much the same story. The difference of note is the absence of statistical significance of the first lag of the construction income. This is likely due to the use of the highway presence dummy that sweeps construction income changes from the model. In this model, the highway presence dummy resulted in reduced incomes in Kanawha County (the urban terminus of the highway). No other counties experienced impacts that were of statistical significance.

The final model is a limited 'treatment' model of the highway impact on income growth. In this model, the negative impact of Corridor G on Kanawha County persisted, but with Lincoln County enjoying positive and statistically significant impacts.

The magnitude of the highway contribution was small in every instance. In Kanawha County, the impact on growth was a roughly 5 percent reduction in the actual growth rate. Growth enhancement attributable to Corridor G was likewise negligible at the county level. These findings are consistent with earlier work (Holtz-Eakin and Schwartz, 1994: Chandra and Thompson, 2000) in finding little specific support for infrastructure types. It does however suggest that human and private capital play a significant role in growth.

Though this modeling effort directly addresses spatial autocorrelation, a problem not fully addressed in earlier research, it still fails to address some of the key concerns of these earlier studies, namely the level of aggregation remains quite high. In essence, this model does not get at the basic questions regarding firm level productivity changes attributable to highway construction. This recommends another approach to modeling the impact of highway impact at the firm level.

Approach 2: A Model of the Productivity Impact of Infrastructure

The direction of formal modeling of *New Growth Theory* reflects more recent interest concerning research and development and human capital. One direction of interest in this research is to evaluate the productivity enhancing value of public infrastructure. A full treatment of new growth theory, while outside the scope of this study, would include a formal treatment of technological change and increasing returns to investment. The exploratory analysis offered in this study will present an ambitious modeling effort that addresses empirical questions of interest. The basic growth model offered here is a production function:

Equation 2

$$Y = f(K, G, L)$$

where output per worker is a function of exogenously determined infrastructure and firm capital. The exogeneity of public infrastructure rests on the assumption that the marginal cost of providing local infrastructure is largely unnoticed by firms.

Assuming an explicit functional form to this production function is fraught with challenges. However, for flexibility and ease of exposition, and with an eye towards empirical specification the assumption of a constant elasticity of substitution function of the form:

Equation 3

$$Y = G^{\alpha}\left[w_{L,i,j}L_{i,j}^{\rho} + w_{K,i,j}K_{i,j}^{\rho}\right]^{\frac{1}{\rho}}$$

The CES parameter, Δ, will vary by industry in an empirical specification, and provides justification for industry control variables that will be included in the several empirical specifications. For simplicity we normalize Δ=1. Similarly, the form of substitution of capital for labor will vary significantly, only by industry. This permits the adoption of linear substitution technology of the form $K_i = \Delta L_i$. Normalizing Δ permits the reduction of the CES function to:

Equation 4

$$\frac{Y}{2L} = G^{\alpha} \qquad \forall \rho = \psi = 1$$

In modified logarithmic form[6] this is:

Equation 5

$$\ln\left(\frac{Y}{L}\right) = \alpha \ln G$$

This clearly lends itself to estimation of the sensitivity of output per worker in individual firms to public infrastructure investment. These types of specifications are commonly employed (e.g. Hall and Jones, 1999). A benefit of a generalized specification is that it permits empirical controls for industry specific variation in the CES and substitution parameters. We examine the specification (dropping logarithmic notation) of:

Equation 6

$$\frac{Y}{L} = a + b\phi + e$$

where

Equation 7

$$\phi = \delta K_i + \beta G + u_i$$

The specification of this empirical model permits the estimating of the average product of labor for firm *i* in industry *j* on a matrix of control variables *K* and public infrastructure, *G*. This process permits an evaluation of the robustness of the assumptions underlying equation 2

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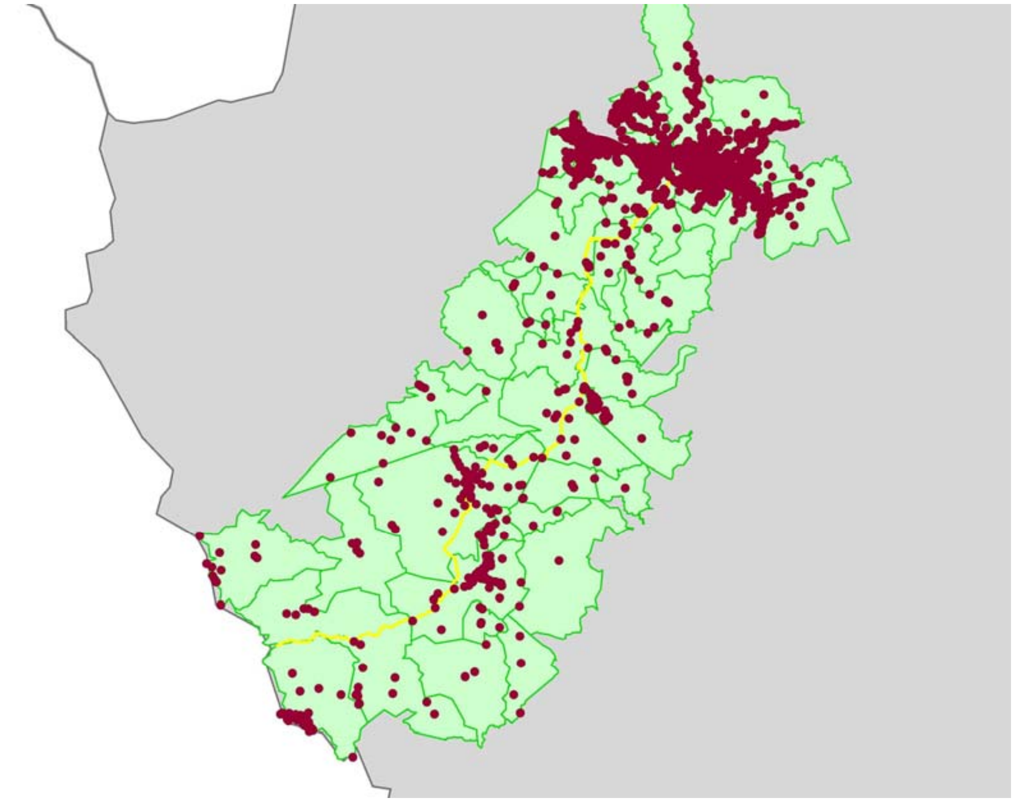
[6] Note that per capita production (Y/L) is treated as an integer in this and most economic analysis, this explains the treatment of this variable when performing the log transformation.

and 3, as well as the all-important parametric evaluation of infrastructure. This econometric specification will be tested on a novel set of data. This model presents only a basic framework for firm level response to infrastructure. Of additional interest is the regional response.

Corridor G offers a useful area for examining the impact of a development corridor. We will examine firms located in zip codes that are within 5 miles of the corridor. This permits the examination of roughly 7,500 firms. Data include revenues, employment, 6-digit SIC classification, ownership type and tenure of firm. Roughly 15 percent of firms lack the full set of necessary data (primarily employment) and so are omitted from the testing. To these data we add regional demographic data at the zip code level as well as a number of count variables for particular amenities in six classifications (e.g. number of hospitals, number of retails centers, etc., in zip code). These are treated as controls for other types of infrastructure.

These data populate a standard production empirical specification outlined in equations (5) and (6) above. To this we use two measures of the proximity of firms (Euclidian and road distance to Corridor G). These variables serve as a proxy of efficiency of public infrastructure. These latter data were estimated using a GIS-T algorithm on latitude and longitude estimates of firm location provided by the Dun and Bradstreet Marketplace database. The standard West Virginia mercator projection was employed. The process for estimating these travel distances involves overlaying the firm spatially on a digital commercial map. These maps are similar to those used by the logistics and delivery industries. These maps include nodes that distinguish changes in road characteristics such as intersections, curbs, pavement types and additional lanes in public roadways. The routing algorithm measures the distance from the firm, to the nearest node, and subsequently the distance to Corridor G by the shortest route.   The West Virginia portion of this is illustrated in Figure 2.

Figure 2, Corridor G and Associated Firms in West Virginia



Geographic omissions due to obvious errors in these data were under 2 percent. Summary statistics for selected data appear in Table 2. Empirical results on selected rural zip codes and industries appear in Tables 3 and 4 respectively.

Table 2, Example Summary Statistics of Sample Firms (7,062 observations)

	Employees	Sales ($1,000)	Average Product of Labor ($1,000's)	Euclidean Distance (feet)	Road Distance (feet)
Mean	11.61	735.54	89.82	15,977.16	26,710
Median	3	100.00	50.00	10,820.63	18,429
Maximum	1,800	668,600.0	1,181.49	60,590.63	137,27
Standard Deviation	45.07	9,960.5	88.33	13,456.51	25,049
Skewness	20.8	47.46	62.98	0.314	1.03
Kurtosis	647	2,866.09	4,495.0	2.42	3.64

Table 3, Results of the Spatial Productivity Model: Rural Counties Only, Euclidean Distance, t-statistics in parenthesis

Variable	**Rural, 1 Emp**	**Rural, < 5 Emp**	**Rural, < 10 Emp**	**Rural, < 25 Emp**	**Rural, < 50 Emp**	**Rural, < 500 Emp**
Intercept	12.8	11.6	11.59	11.73	11.78	11.76
	(11.16)	(25.12)	(26.65)	(28.25)	(28.21)	(28.41)
Log of distance in feet	-0.13	-0.057	-0.0058	-0.07*	-0.078*	-0.07*
	(-1.12)	(-1.18)	(-1.28)	(-1.63)	(-1.79)	(-1.74)
Square of log distance	1.05E-10	1.47E-10*	1.46E-10*	1.26E-10*	1.52E-10**	1.45E-10**
	(0.93)	(1.88)	(1.98)	(1.79)	(2.16)	(2.06)
Branch binary	0.012	0.02	0.011	-0.004	-0.03	-0.04
	(0.25)	(0.24)	(0.15)	(-0.06)	(-0.53)	(-0.60)
Cemeteries	0.00015	-0.0072	-0.009	-0.01	-0.009	-0.0088
	(0.068)	(-1.49)	(-2.05)	(-2.36)	(-2.03)	(-1.97)
Churches	-0.014	0.017	0.01	0.01	0.01	0.01
	(-1.78)	(1.95)	(2.11)	(2.11)	(1.94)	(1.74)
Hospitals	0.027	-0.18	-0.18	-0.16	-0.144	-0.11
	(0.56)	(-1.88)	(-2.01)	(2.11)	(-1.62)	(-1.26)
Malls	0.28	-0.28	-0.28	-0.31	-0.30	-0.33
	(1.30)	(-1.43)	(-2.10)	(-1.83)	(-1.82)	(-2.02)
Schools	0.011	0.004	0.008	0.014	0.011	0.01
	(1.14)	(0.40)	(-1.54)	(1.17)	(1.12)	(1.27)
Adj-R^2	0.04	0.009	0.019	0.09	0.01	0.01
F-Statistic	2.15	1.82	2.12	2.05	2.2	2.24
Observations	194	663	815	900	929	948

* denotes statistical significance at the 0.10 level, ** denotes statistical significance at the 0.05 level and *** denotes statistical significance at the 0.01 level

Table 4, Selected Industry Regressions, Rural Counties Only, Euclidean Distance, t-statistics in parenthesis

Variable	Rural gasoline stations	Rural Retail (multi-type)	Rural Manufacturing
Intercept	21.78***	11.733***	7238634***
	(6.14)	(32.00)	(1.23)
Log of distance in feet	-1.319***	-8.75E-05***	-768135
	(-3.14)	(-2.38)	(-1.22)
Square of distance	-3.22E-11	1.68E-09**	0.000711
	(-0.02)	(2.30)	(1.24)
Branch binary	0.97	0.15	-807609
	(2.95)	(0.67)	(-1.10)
Cemeteries	-0.06	-0.004	-422
	(-1.44)	(-0.32)	(-0.10)
Churches	0.46**	-0.002	-1747
	(2.31)	(-0.10)	(-0.14)
Hospitals	4.00	0.15	-131656
	(1.23)	(0.62)	(-0.76)
Malls	-20.82*	-0.516	144603
	(-1.72)	(-1.52)	(0.57)
Schools	0.06	0.02	-12590.75
	(0.63)	(0.65)	(-0.823)
Adj-R^2	0.70	0.06	0.18
F-Statistic	4.53	1.98	4.95
Observations	13	110	137

* denotes statistical significance at the 0.10 level, ** denotes statistical significance at the 0.05 level and *** denotes statistical significance at the 0.01 level

Interpretation of these models is also straightforward but warrants some discussion. In the first model (not shown) a sample of over 7,100 West Virginia firms, including a relatively urban Kanawha County, finds no statistical significance of the highway. This model does not provide support for increasing returns to infrastructure in an urban area. The models illustrated above remove Kanawha County from the estimation (though it is partially rural). In these models, illustrated in Table 3, the models separating firm size show an increasing level of significance. However the magnitude of the parameter estimates are not statistically significant across firm size. Similarly, this disaggregated model strongly supports an interpretation of increasing returns as exhibited by the significance of the squared term. This provides support for the hypothesis that public infrastructure enjoys increasing returns in a rural setting.

The industry specific regressions are illustrated here to present information on the range of results obtained when smaller, industry specific analysis is performed. Also, increasing returns is implied for some industries.

Analysis performed on the estimates of actual road distance serves as an alternative measure of infrastructure quality. There are no implied preferences for the road distance or Euclidean distance measures. In a practical sense, it would appear that road distance would be a preferential measure; however, since we have placed no restrictions upon the source of benefits (supply or demand) there are plausible conditions where both would apply. While actual travel costs should be reflected in road distance (versus Euclidean distance), making the travel distance preferred, there are conceivable instances where both costs and demand could be better represented by Euclidean distance. For example, advertising costs may be lower for firms that are more proximal to the road (and can thus use on-site signage).

In these estimates in the entire sample, distance played no role in the productivity of firms. As with the earlier estimates, this changed in rural areas. When assessing the impact of infrastructure in rural areas only, the distance variable was statistically significant. The results of the aggregate estimate appear in Table 5.

Table 5, Aggregate Regression, Rural Counties Only, Road Distance as Infrastructure Variable

Variable	Coefficient
Intercept	598884.1*** (6.08)
Road Distance (miles)	-4073.885* (-1.70)
Per Capita Income	-8.530441 (-1.16)
Number of SICS in Firm	4110.79 (0.16)
Number of Employees	-452.9382 (0.31)
Households in Zip Code	3.914701 (0.78)
West Virginia	-400563.8*** (-5.28)
Adjusted R-squared	0.034782
Observations	1,072

denotes statistical significance at the 0.10 level, ** denotes statistical significance at the 0.05 level and *** denotes statistical significance at the 0.01 level

Interpreting the findings in this portion of the study provide some support for the hypothesis that a positive productivity impact related to the physical proximity of infrastructure may result. This impact varies across industries and is apparent only in rural regions. Employing the point estimates of the distance parameters provides some scale of the impacts. Using the Euclidean distance, we find that a roughly 1.3 foot decrease in the distance of the firm to Corridor G, raised worker productivity by roughly one dollar a year. Using the road distance, the impact increases to a one dollar increase for every 0.77 feet the firm is closer to Corridor G.

To place this in context, halving the average distance to Corridor G would increase the average output of a worker by roughly $10,010 (Euclidean) or by $10,250 (road). Notably this is a point estimate. This finding suggests a non-trivial impact of infrastructure on firm productivity in rural regions. There is much that remains unknown regarding the contribution of infrastructure to economic activity.

The specific question outlined above provides the basis for estimation that should answer a wide variety of questions related to development policy. These include the impact of related amenities on firm productivity, concentration and market power potential by industry in small regions, impact of various factors on regional unemployment and a host of others. The direction of causality also remains a concern.

The infrastructure model outlined above cannot capture the dynamic spatial impact of infrastructure. To understand the time impact of the infrastructure, and its impact across broad space and time we will have to rely on different data sets and different modeling approaches. One is detailed below:

Approach 3: Models of Sustainability

Sustainable growth is a much studied phenomenon in the development literature. It has not, in the context discussed here, appeared extensively in research conducted by economists. The potential empirical components of sustainability are too numerous to review here, instead a narrow focus will have to suffice.

The first area of sustainability that matters is whether firms survive longer due to exposure to infrastructure. Since our data on individual firms includes tenure, examining the correlation between age and proximity to the new highway offers a first test of sustainability. Using the rural model illustrated in Table 3 we estimate the ageing impact of highways. This estimate revealed no correlation between the age of the firm and its Euclidean distance to the highway.

A second concern of sustainability is the existence of structural change in the regional economy that may be correlated with the infrastructure investment. In order to test this, a similarity index for each county was constructed. This method measures the difference from the state mean of each county's per capita income in each of the ten 1-digit SIC codes. The absolute value of the difference is summed and subtracted from the base index of the state (which is 100). The result of this is a county index of difference from the state which is bounded [0, 100]. It is based on Bernat and Repice [2000] and takes the form:

Equation 8

$$S_{i,t} = \left[1 - \left(\sum_{i=1}^{n} \left| S_{i,s} - S_{i,n} \right| \right) \right] * 100$$

where the similarity index for each county, *i* in time *t*, is the sum of the absolute deviation in the county share of income in industry, s from the state share. This is indexed to 100.

The similarity index is then incorporated into a spatial vector autoregression similar to that outlined in the first approach model. We include in this model a presence dummy for Corridor G along with the spatial term. The results of this sustainability model permit estimates of the influence of the highway on structural differentiation in each county. This sustainability measure derives its name from the convergence hypothesis in macroeconomic theory. Results appear in Table 6.

Table 6, Sustainability Regression

	Variable	Coefficient	Std. Error	t-Statistic
	Intercept	0.481978***	0.122611	3.930936
Boone	**Sim t-1**	-0.010777***	0.004032	-2.672595
Kanawha		-0.005319***	0.001263	-4.212780
Lincoln		-0.004519	0.003738	-1.208965
Logan		-0.005831*	0.003294	-1.770053
Mingo		-0.006903***	0.002182	-3.164011
Boone	**Spatial** N	0.022406***	0.004903	4.569554
Kanawha		0.000133**	5.63E-05	2.352554
Lincoln		-0.000465	0.003985	-0.116697
Logan		0.004040	0.005180	0.779893
Mingo		-0.001823**	0.000774	-2.354300
Boone	**Spatial** N **t-1**	-0.015452**	0.006125	-2.522716
Kanawha		-0.000164***	5.29E-05	-3.092003
Lincoln		-0.001735	0.003193	-0.543399
Logan		-0.000652	0.007329	-0.088975
Mingo		-0.000730	0.000749	-0.975621
Boone	**Per Capita Income**	-1.147564	1.329590	-0.863096
Kanawha		0.105572***	0.012806	8.244041
Lincoln		0.518074	2.354796	0.220008
Logan		-3.169532*	1.825321	-1.736424
Mingo		1.883405**	0.917917	2.051825
Boone	**Per Capita Income t-1**	1.615680*	0.962064	1.679390
Kanawha		-0.063391***	0.004491	-14.11449
Lincoln		2.111150	2.798866	0.754287
Logan		2.898644	1.935435	1.497671
Mingo		-0.946908	0.668508	-1.416451
Boone	**Population**	3.31E-05	2.42E-05	1.367141
Kanawha		4.94E-07***	4.58E-08	10.79293
Lincoln		-2.75E-05	2.83E-05	-0.971170
Logan		-4.31E-06	2.12E-05	-0.202869
Mingo		2.40E-05***	7.90E-06	3.042848
Boone	**Population t-1**	-4.25E-05*	2.54E-05	-1.671157
Kanawha		-3.46E-07***	7.17E-09	-48.26141
Lincoln		2.07E-05	1.81E-05	1.148112
Logan		6.70E-07	2.06E-05	0.032612
Mingo		-1.73E-05***	5.37E-06	-3.231579
Boone	**Corridor G**	-0.025441	0.027540	-0.923796
Kanawha		7.27E-06	0.000302	0.024078
Lincoln		-0.016403	0.016303	-1.006135
Logan		-0.023176	0.016426	-1.410922
Mingo		0.018900**	0.007542	2.505905
Adjusted R-squared		0.357208	F-statistic	
Durbin-Watson stat		2.164474	Prob(F-statistic)	

* denotes statistical significance at the 0.10 level, ** denotes statistical significance at the 0.05 level and *** denotes statistical significance at the 0.01 level

These results require some interpretation. First, analysis of contemporaneous and lagged dependent variables in the spatial vector autoregression (similarity index, population and per capita income) speak little to sustainability in this context. The spatial variable, N, serves as a correction for spatial autocorrelation. What emerges as important in this context is that the Corridor G presence dummy was positive and strongly significant for Mingo County. This means that the completion of Corridor

G strongly influenced the similarity index (a measure of economic diversification) for Mingo County. This suggests a long-term impact on the county's economy has resulted from the presence of the Appalachian Development Highway. However, to better understand this relationship it is important to understand what economic diversity does, and does not do to regional economies.

Regional sustainability implies many things. Among these are a stable economic growth rate and the convergence of growth. Public capital may influence these factors as the preceding empirics illustrate. Notably there is no correlation between growth rates and similarity, thus economic diversity is not a useful policy goal solely due to growth benefits that may arise from it. Economic diversity may however, reduce the magnitude of cyclical fluctuations. This may be exemplified by the skewness of the similarity index. Skewness is the higher moment that describes the 'tail' of the distribution of a sample. Negative skewness suggests a thick negative tail, while a positive skewness suggests a thick or elongated positive tail. In terms of growth it is clear that a negatively skewed distribution leads to deeper recessions. Analogous dips in the skewness of the similarity index may occur as regions become less similar to the mean (hence becoming less diverse). This, in turn leads to potentially greater cyclical fluctuations or regionally hard recessions. Clearly the completion of Corridor G has made the economy of Mingo County more like that of West Virginia as a whole. This reversed a 25-year trend and is likely to result in a more stable regional economy. There was no effect on the other counties.

Corridor G and Small Businesses

The findings above represent only the "tip of the iceberg" of a considerable amount of analysis within the context of the models outlined above. One important piece of this research, outlined at the beginning, was the focus on small business impacts. As stated previously, there were no economic impacts that were attributable to firm size alone. This means that small businesses enjoyed, but not disproportionately, the benefits of Corridor G.

Summary and Conclusions

The findings presented in this paper offer three distinctly different techniques of infrastructure analysis. The first, a cross county growth regression, extended the methods of earlier research by Holtz-Eakin and Schwartz [1994] and Chandra and Thompson [2000]. These dominant papers provided little support for the claims that productivity growth ensues from highway construction. The first model in this paper substantially supports these findings for Corridor G. We find that Corridor G's construction has not added net economic activity to the region. However, the potentially obscuring factors of aggregation warranted more detailed research. This was performed in the second model.

The second approach used cross sectional data in a regional production function to test the impact of highway presence on productivity. These results were startling. In rural counties firms with more than one employee experienced a significant and positive increase in productivity due to proximity to Corridor G. This spatial measure was accomplished by measuring the Euclidean distance from each firm to the highway using GIS-T methods. The results were more profound in industries with transportation and time costs were present for either producers or consumers. The results were important since they imply a non-trivial impact, but one which should be interpreted with caution.

Finally a sustainability model was employed at the county level to evaluate the impact of the road on regional economic diversity. There was strong evidence that the rural terminus of completed construction

(Mingo County) enjoyed considerable increase in its economic diversity, reversing a 25-year trend.

This research answers an important question regarding highway productivity impacts. Several other factors remain unknown. Among these are the impact of other types of infrastructure such as water, sewer, gas and electricity on regional growth. This has important implications for follow-on road construction in regions.

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